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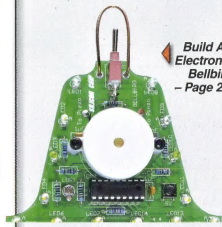

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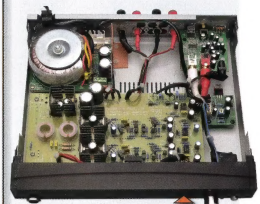

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Publisher's Letter

Should Australia continue to subsidise the car industry?

There is considerable debate at the moment about whether the level of subsidies granted to the Australian car industry should be continued by the Government. As with many debates about government action, it is not a simple question and whichever way it is finally resolved will have major ramifications for the tens of thousands of people either directly or indirectly employed by the car industry and for the whole Australian economy.

Much of the debate hinges around high labour costs in Australia, apparently low productivity and falling sales of locally manufactured cars. The real problem is the last item, not enough sales. While the cars manufactured by Ford, Holden and Toyota are undoubtedly well-designed and competitive with equivalent cars made overseas, there simply are not enough of them being sold to make production viable.

But what is the real reason not enough Australian-manufactured cars are being sold? Virtually zero tariffs. In the past, Australian cars had considerable protection by dint of the high tariffs levied on all imported cars. Over the years, these have been whittled away by successive governments and reduced to zero for cars sourced from countries with which we have free trade agreements, as in the case of cars sourced from Thailand, for example. That is why we now have such a wide range of motor vehicles. Years ago, the choice was much more limited.

Make no mistake, tariffs are very beneficial for a country's employment, as they make it difficult for imported products to compete with those produced locally. But the downside of high tariff protection is that it makes all products (ie, those protected by tariffs) more expensive. So whether or not a person decides to buy a locally made or equivalent imported product, the cost will always be higher than if there were no tariffs at all. As well as that, as with the car industry, with low tariff protection, the range of products available is bound to be dramatically broader.

So where is this headed? Will the Government give in to all the special pleading and carry on the subsidies for years to come as the sales of Australian cars continue to decline? Or will they bite the bullet and say enough: no more subsidies?

I suggest that we can look to history for the best guide to what the decision should be. In 1973, the Whitlam Labour Government reduced all import tariffs by 25%. By any measure, it was a precipitate decision and the almost immediate result was that a large portion of the Australian electronics industry was wiped out. Probably more than 100,000 people lost their jobs in the years immediately following. Many people would have regarded it as a complete disaster.

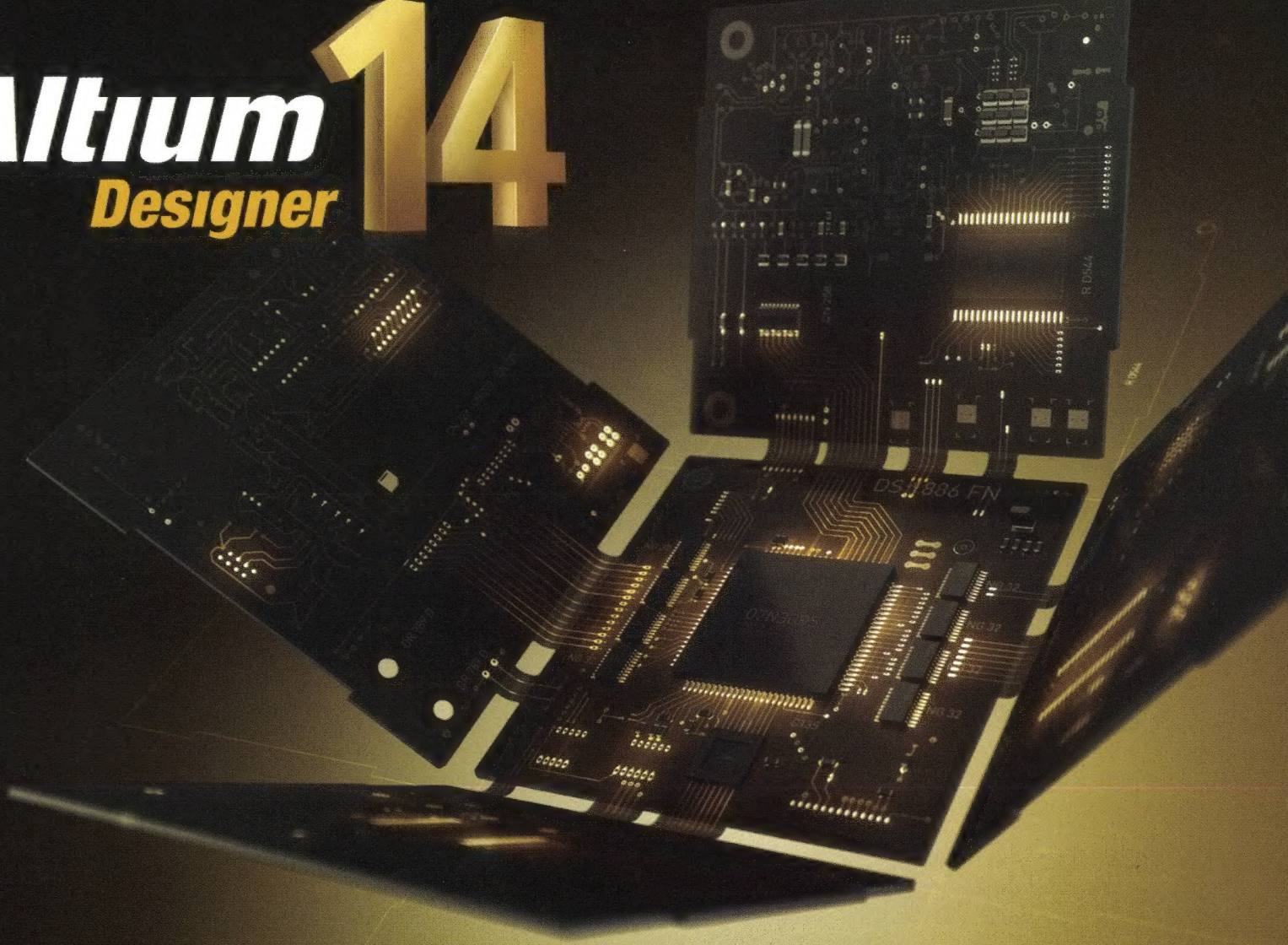
But looking at it with 40 years of hindsight, it was a brilliant decision, and I make that statement as one who had worked in the electronics industry. Up to that time, imported electronic appliances such as TV sets, stereo systems, radios and other items were virtually unavailable or very expensive. Then came the flood, mostly from Japan, and prices of TVs and other consumer electronic appliances dropped overnight. They have been dropping ever since.

Can anyone imagine Australia ever producing the huge range of electronic equipment that we now enjoy, behind a 25% tariff barrier? Clearly that is preposterous. With a population of only 23 million people, how could an Australian electronics industry ever hope to compete with all that is made everywhere else? Australia still has an electronics industry but as in most other western countries, it is confined to specialised or niche products.

Personally, I regret that we will lose much of the large skill base and all the employment that pertains to the car industry but I think it is inevitable, whether subsidies are maintained or not. In the long term though, Australia will be better off.

Leo Simpson

Altium Designer 14



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Coal-fired power stations are defunct

They finally shut the power station I once worked at. Someone must have toured the place and realised it was a museum piece.

The thing that made me realise power stations as we know them are defunct was working at a coal-fired power station. There are millions of moving parts and as the years go by they all need maintaining.

Nuclear power stations would be even more onerous as tremendous safety precautions would add to the bill. Nuclear power stations would still have the same efficiencies as coal I reckon.

Guy Reece,
Kirwan, Qld.

Comment: many of Australia's large coal-fired power stations are more than 40 years old and as you say, increasing maintenance is a costly problem and they should replaced but governments seem reluctant to commit to new base-load power stations. Apart from nuclear or closed-cycle gas-fired power stations, there are no other systems for generating base-load power in Australia.

Nuclear power stations are generally less thermodynamically efficient because boiler temperatures and the temperature of the super-heated steam are generally less than in modern coal-fired power stations. Closed-cycle gas-fired power stations are presently the most thermodynamically efficient in existence.

Electronic voting is not necessary

I fully agree with the Publisher's Letter in the October 2013 issue in that electronic voting is not needed and that most problems can be resolved by simple changes of law and procedure.

I have fundamental concerns about the reliability of an electronic system and the implications if it "goes down". Effectively, paper back-up systems would still be required in case an individual polling place or the main system failed. Paper ballots can also be re-counted in a way electronic votes cannot.

From my own experience in charge of a polling place we have a very good paper system now, with good checks and cross-checks. In the case of an unprincipled government, paper ballots are also less open to manipulation than "hidden" electronic systems that are not open to any scrutiny.

I also resent the possibility of being *made* to cast a valid vote. I do always cast a valid vote, however I prefer a system of compulsory ballot box attendance to one of compulsory voting. My right (as I see it) to vote informally is, I think, a key counter-balance in a system that requires me to attend. The level of informal votes, as you rightly point out, has something to say. If, under a simplified system, the level rises, this is a key indicator of societal dissatisfaction with the overall political process.

My wife is from the USA and I have observed electronic systems in use. People dislike them and distrust them. As you stated, they also require attendance at a polling place. The thought of

Supplier-driven technology is desirable

I refer to the letter entitled "Supplier-Driven Technology Is Not What The Customer Wants" (Mailbag, page 6, November 2013). I disagree with the title and content of the point the author wants to make. I think the title should have been "not what this customer wants".

Consumer take-up of tablet computers has been remarkable and based on the fact that it is in fact what the consumer wants. There's a healthy legacy of failed products that manufacturers may have tried in the past however tablets are by no means one of them. Smart manufacturers of these devices are simply meeting the demand.

I appreciate the "build it and they will come if you market it right" view however the proof of the pudding and subsequent taste is the fact that the adoption rate of tablets is so prolific across so many areas of learning, business, agriculture,leisure etc and does in fact make life easier when compared to lugging a laptop around.

I use an Android 7-inch tablet for my business and being able to use a computing device small enough to be only marginally less portable than a mobile phone but miles easier than a laptop is fantastic. There is next to no start-up time compared to laptops, they are more portable, have longer battery life and can access multiple email accounts, the internet, Skype, blogs, newspapers (I'm a newsagent) and all the other well-publicised and appreciated applications that are available. Yes I can do most of this on my smartphone but being an older person, I need the extra real-estate a tablet screen offers.

I appreciate that tablets may be viewed as a desirable item to steal but no more so than a mobile phone, wallet, car keys or a laptop. The solution, just be more careful!

Personally, I find that I am far more productive with the tablet compared to the laptop which I sometimes couldn't be bothered starting up. And if that's the result of a manufacturer telling me what I want, then thanks.

Angelo Giuffre,
Jindabyne, NSW.

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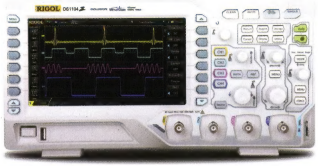

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Mailbag: continued

Diesel-electric locos point the way for hybrids

With respect to the Publisher's Letter on the topic of hybrid cars in the November 2013 issue, I find that history is being ignored.

One of the major losses in a normal car is the transmission. An all-electric car removes this but limits range. So the obvious solution is to modernise the diesel-electric train architecture.

A new generation hybrid would be a motor-generator with electric drive to the wheels. This is one way to reduce the excessive hybrid costs, also reduce weight and get a boost in the hydrocarbon fuel efficiency as well.

I also like the nippy Nissan Leaf electric car.

Alan Bothe
Manly, Qld.

Comment: it is doubtful whether the overall efficiency of a motor-generator-motor system would be better than a modern gearbox such as a CVT, DSG or 6-speed automatic gearbox. In fact, there might also be a weight penalty.

an internet-based system is simply too frightening to contemplate! To have any decent security at all, they would require very high levels of complexity – a further alienation – otherwise they would be open to "ambush" voting programs.

I'm not that happy about the census having gone that way. At least there is less reason to manipulate the census as compared to the outcome of an election.

Angus Witherby,
Mordialloc, Vic.

Electronic voting is an advantage for people with a disability

I am a visually-impaired reader who cannot read print. I receive SILICON CHIP as an audio book from Vision Australia which I download from the Library Services each month.

I note your Publisher's Letter in the October 2013 issue regarding electronic voting. In presenting your arguments against this form of voting, you refer to people with disabilities who would find it difficult to use a computer. However, you do not recognise the many blind or visually-impaired voters who would benefit from being able to vote electronically.

I have been using a computer fitted with screen-reading software since 1985. This software enables me to use a computer in much the same way as a sighted person does, even though I cannot read what is displayed on the monitor. Before I retired, this remarkable software enabled me to confidently handle my responsibilities as senior law clerk in a legal office. I also spent nearly 30 years as a member of about 15 Standards Australia technical committees, mostly in the automotive area. More recently I was able to respond to my obligations to complete the last census questionnaire on line.

For the first time this year, I was able to vote using the new system of telephone voting provided by the AEC instead of having to rely on my wife to explain all the voting options and then fill in my voting papers. The telephone voting enable me to vote independently, although the new system was quite time-consuming. The AEC officer was required to read out to me all the political parties and candidates before I could vote. An electronic voting system by contrast would be a lot quicker and would certainly be more private.

To a sighted person, voting using a computer probably seems impossible. There are, however, an increasing number of blind or visually impaired people who are very computer-literate and would easily cope with electronic voting.

Barry Napthine,
Woodend, Vic.

New regulations on wireless microphones

The Australian Communications and Media Authority (ACMA) is writing to advise about the changes affecting the use and supply of wireless

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Mailbag: continued

microphones in Australia. To that end, ACMA has published a series of fact sheets targeted at 'plug and play' users, professional users and suppliers.

The ACMA also has an online wireless microphones hub, which is a one-stop shop for all the information you need to know and resources to help people prepare for the change. Readers can sign up to our free, monthly e-bulletin which provides updates on the ACMA's work on wireless microphones. The recent changes are as follows.

Many wireless audio transmitters (which includes wireless microphones) currently operate in the frequency range 694-820MHz. From 1st January 2015, it will be illegal to use these devices as this spectrum will be used to deliver 4G mobile broadband services. ACMA has introduced two measures to protect consumers from being sold wireless audio transmitters that cannot be used after 1st January 2015.

From 17th September 2013, suppliers must include a warning label with each wireless audio transmitter that operates in 694-820MHz advising potential buyers that the device will be illegal to use after 31st December 2014. From 1st January 2014, suppliers will no longer be able to import, manufacture or sell wireless audio transmitters in Australia that operate in 694-820MHz.

ACMA strongly encourages people to check their existing equipment now to make sure that they can continue to use it after 31st December 2014. If you're unsure how to do this, check your user manual or contact your supplier for help. Contact your supplier to see if you can re-tune your existing equipment so it uses a different frequency range. The main alternative frequency ranges are 520-694MHz and 1790-1800MHz. A full list of alternative frequency ranges is available on the ACMA's website.

If you need more information, check out our wireless microphones hub at www.acma.gov.au/Industry/wirelessmics or email us at freqplan@acma.gov.au

Anna Cheung, Spectrum Engineering Section, Australian Communications and Media Authority, Melbourne, Vic.

Incorrect statements lower the standard

While enjoying the theory, design and practicality of recent SILICON CHIP projects, I am concerned at what I consider to be incorrect information or statements used to justify or support the reasoning behind them. The first was the "Rugged Battery Charger" in April 2013. I applaud the re-purposing of the iron-core halogen transformers and the detailed technical explanations behind the design. It is an informative demonstration of power supply design principles and pulse-charging of batteries.

Unfortunately the statements regarding "we couldn't find a charger of this power for under $100" and "a basic car charger that can put out a good 10A or so" are misleading at best. The 10A is only achieved as peak pulse currents while the average current, as stated, is much lower at around 3A. As noted, the charge current is uncontrolled, so why

Nostalgia for 2N3055 transistors

I read the comment that ". . . the 2N3055 is a very old transistor . . ." (Mailbag, page 8, November 2013) and it reminded me that I bought my first 2N3055 prior to 1966. I know this because I paid £2/5/– (ie, before decimal currency). It was used to regulate the high-voltage supply of a mono valve amplifier, using 6CA7s in ultra-linear configuration.

The input to the regulator was about 460V and the output was regulated by feeding the base from the voltage doubled output of a 150V 30mA transformer, giving just over 400V. The 2N3055 was mounted on a small heatsink under the chassis, supported by insulating standoffs.

The amplifier gave good service and was sold in working condition when we had a garage sale in the late 1980s. Its successor was a stereo EA design, using 2N3055s as the output transistors. By that time, they were much cheaper (about 60c each). That they are still sold is testimony to their flexibility and robustness.

Alan Cashin,
Islington, NSW.

risk your $200 battery?

In a Jaycar advertisement in the centre pages of the same issue, there is a promotion for an intelligent switchmode "12V 3.8A 5-stage Multi Stage Battery Charger" for the sum of $79.95. That's 3.8A continuous with fully and safely controlled charging.

While not so technical or innovative, the best use I've found so far for these transformers is to power multiple 12V AC/DC MR16 LED globes, which are easily available in wattages up to 6-7W. In this way, the downlight fittings themselves can also be re-purposed by retrofitting with LED globes and using them in an alternate location. Two 6W MR16 LED globes will provide a similar or better illumination to a 50W MR-16 halogen globe at a third of the power consumption.

The second was the "Lithium Battery Pack For Your Cordless Drill" in the October 2013 issue. I again applaud the concept of re-purposing rather than tossing equipment in the "circular file", and totally agree that repairing, repacking or replacing Nicad and NiMH battery packs can be a problem.

The lithium-based portable power tools being sold currently are indicative of the practicality of replacing nickel batteries with Li-Po cells.

I have successfully repacked and replaced Nicad and NiMH battery packs, and also replaced Ni-based batteries with Li-based technologies by using the same Li-Po battery packs ignored in the breakout titled "Commercial Li-Po Tools: Do They Check Cell Status?".

It seems that someone did not do their research very well before making sweeping statements like "the easiest way was to scour the shelves at a couple of major hardware stores – and we have to report that we didn't find a single tool that had any form of charger multi-connector". This assumption means that pretty much everything in the break-out is incorrect. Given that only the charger connections were inspected, there was a failure to comprehend

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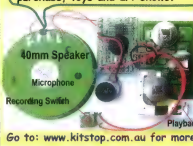

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Mailbag: continued

the differences between the "hobbyist" technologies and "consumer/trade" technologies.

A look at the internals of a Li-Po battery pack from a medium-priced 14.4V cordless drill shows that the complex charge control, cell equalisation and low-voltage shut-down circuitry is in the battery pack, not the charger – so it does not need "a form of charger multi-connector".

The "charger" is then only a regulated power supply and status indicator. I also have an 18V version of the same brand drill which also has the charge and control circuitry within the battery pack. The small extra weight of the circuit board is negligible compared to the weight of the tool.

The production volumes of consumer and trade products makes this cost effective, and also ensures the best possible battery life. The hobbyist-type batteries are designed to maximise power-to-weight ratio and to minimise volume, so their charge control circuitry has always been deliberately external to the battery packs.

Gary Brewer,
Croydon Hills, Vic.

Comment: while the scope waveforms on page 78 of the April issue show the charger delivering a peak current of 9.58A, equivalent to an average current of 3A, that does not indicate the maximum capacity of the charger itself. It should deliver a maximum current of about 10A into a flat battery.

iPod charger adaptor query

I found the iPod Charger Adaptor project (SILICON CHIP, August 2013) to be rather interesting but I wonder how necessary it is.

Some time ago, my oldest son bought an iPhone 4 with a smashed screen cheaply and he got a new screen on eBay and repaired it. He wanted to be able to charge it in his car and he knew I had a small USB charger that plugs into the car's lighter socket, that I'd bought a few years ago. He asked me if he could borrow it, so I gave it to him. He came back quickly and said it didn't work.

I dismantled it and found, as I suspected, that the D- and D+ connections on the USB port were floating, with only the V_{CC} and GND lines connected to the circuit. I then simply bridged the D- and D+ connections on the USB port and put it back together again and gave it back to him to try. He came back and said that it now worked and asked what had I done to make it work. I told him what I'd done and he asked what that was supposed to do.

I explained to him that when you plug a device into a USB port, the device asks the USB port for permission to draw current for charging. If the D- and D+ lines are open circuit, there is no communication between the device and the port, so the request goes unanswered and the device does not charge. By bridging the D- and D+ connections, it causes the USB port to give automatic permission to the device to draw current.

I'm not sure if this will work for all devices that can use a USB port for charging but we already knew that it definitely works for an iPhone 4. Since reading the SILICON CHIP article, we have rounded up all the other devices we have that can be charged from a USB port and all except one can be charged on this modified USB car charger. The additional devices that can be charged are as follows: iPod Nano 3G, iPod Nano 4G, iPod touch 3G, Samsung GT-E3300 phone, LG K360 phone, Amicroe Touch Tab 2 Tablet and Huawei L300 phone.

While we were doing all this testing, my son commented that all these devices will charge from the car charger, because several or his friends have i(devices) that they charge from similar car chargers (from eBay) without problems. He was right that they all charged.

It's interesting to note that a similar car charger that I bought on eBay more recently, already had the D- and D+ connections bridged when manufactured. It's probably similar to (or the same) as the the units my son's friends use that they got on eBay.

So, I just wonder if anyone thought to just simply bridge the D- and D+ pins on the USB port when researching/designing the iPod Charger Adaptor.

Bruce Pierson,
Dundathu, Qld.

Comment: while it is true that many phones and MP3 players can be charged with the D+ and D- data lines shorted on a charger, this is not necessarily true in all cases. Charging may or may not occur with this charger

configuration and if it does, the charge current will often be much less than 500mA.

In some cases, shorted D- and D+ lines on a charger will show a "charging is not supported with this accessory" warning on the iPod device being charged. This means that you are required to use a genuine Apple charger or use the SILICON CHIP iPod Charger Adaptor which simulates one.

DAB+ digital radio black spots have been filled

Recently, black spots in metropolitan DAB+ coverage have been filled. The main transmitter sites are still Mt Coot-tha in Brisbane, Mt Dandenong in Melbourne, Carmel in Perth and Artarmon in Sydney.

Additional transmitters have been installed at Mt Mee in Brisbane, 101 Collins Street, Melbourne and Central Park in Perth (Mindarie). In Sydney, the extra transmitters are at Westfield Centrepoint, Redfern, Bilgola Plateau, Collaroy Plateau, Gregory Hill and Hawkesbury.

At each of these sites, a 7MHz-wide receiver converts all DAB+ signals down to an intermediate frequency which is then accurately filtered. This signal is then converted back to its original frequency, amplified and then re-radiated on another antenna.

The re-radiated power is either 300W or 500W ERP (effective radiated power).

There is shielding between the receiving and transmitting antennas to prevent oscillations occurring due to feedback. This system works for all three DAB+ signals coming from a single main transmitting site and they are adjacent channels within one 7MHz TV channel.

Alan Hughes,
Mt Hamersley, WA.

Lip sync problems with TV & surround sound

I'm wondering what the cause of lip sync being out on my TV.

For quite some time I've been in the practice of using my stereo amplifier for surround sound for the TV and the sound and picture have been in perfect sync. So why it has slipped out is a total mystery to me. I am using a Telstra T-Box for all channels so the programs are now via the internet.

I now have to resort to just using the TV speakers on their own which is nothing like the quality of sound I was once enjoying. If a reader can solve the mystery I will be grateful.

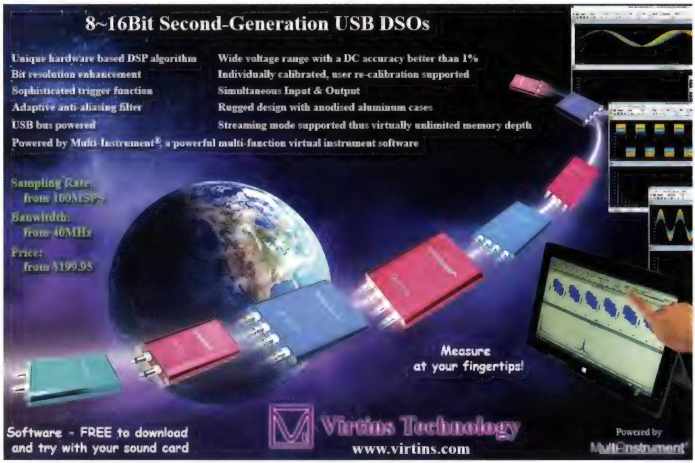
Graeme Scott,
Albury, NSW.

Footnote: the correspondent subsequently found the solution to his lip sync problem. The answer was to feed the TV's optical (TOSLINK) audio output to the amplifier and use that instead of the analog outputs.

Is there a database for remote control codes?

Is there such a thing as a database or registry of remote codes for domestic TVs, receivers, DVD and CD players? Many times I have had to discard otherwise serviceable electronic equipment for want of a remote control.

I went through a phase of trying the



Mailbag: continued

Photos show faulty assembly of Tiny Tim loudspeaker

I'm sure I'm not the first to notice a construction problem in the photographs on page 35 of the Tiny Tim Loudspeaker in the October 2013 issue. Pieces 3 & 4 are butted together differently to the assembly shown in the diagram on page 33. The website reference for the Fostex design indicates that the diagram on page 33 is correct. The construction shown in the photographs changes the geometry of the horn by quite a bit.

If this construction was actually used in the speakers tested by your lab then the graphs on page 34 are no longer valid and your observations on the performance of the Fostex driver versus the Jaycar and Altronics drivers have been compromised.

Keith Ward,
Harden, NSW.

Comment: in fact, you are the only person to bring this mistake to our attention. We asked Allan Linton-Smith whether he had glued the sections up as shown in the photos or was it just a mock-up. He admitted that he had glued them up as shown for his first speaker but then was puzzled as to why internal dimensions did not appear to be correct.

Apparently, it took him a while to realise what he had done and then he had to break the joint between panels 3 & 4. While breaking the joint did damage the plywood veneer the re-glued joint was not visible so it was no great problem. He then glued up the sections for the second speaker correctly.

However he had forgotten this mistake while writing the article and later re-checking the article proofs. He was amazed that anyone had spotted the mistake.

universal units but (and maybe I was just unlucky) it was the devil's own job trying to first find a set of codes that operated the device in question. Almost always, particularly with more complex devices, some function would turn out to be unattainable.

Alternatively, is there such a thing as a device which will capture and store in some retrievable format the complete set of codes for a given device? Is there a 'learning' function if you will, that would allow one to store these codes in a standard format for prospective use down the track when the original remote is destroyed, lost or just dies of its own accord?

A publicly accessible database of remote control codes could become a handy community resource and might even help to stem the flow of e-waste into land fill.

Peter Felton,
Willoughby, NSW.

Comment: you would need to store the IR codes in a learning remote so that you could use it later if the original remote dies. There are plenty of standalone learning remotes available and also some with USB interfaces (eg, USB-UIRT).

We don't think that a comprehensive database of remote control codes exists.

Wind power does reduce coal consumption

I am amazed that any publication, especially a technical one, would print a letter to the editor ("Industrial wind factory refugees" by "Name and address supplied but withheld at writers request", June 2013) stating in part that "Wind-factories don't result in one less scoop of coal being used to generate power"!

I would suggest that the writer is either a total non-logical thinker, has no understanding whatsoever of methods of generating electricity, or is so biased against wind turbines that he/she can't see the wood for the trees, and one can only assume that the writer believes that coal-powered generators continually generate excess power just in case the wind stops blowing, which is of course, pure poppycock!

It is indisputable that in coal-fired power stations, it takes a quantity of coal to generate a kilowatt-hour of electricity. Therefore, for each and every kWh generated by a wind turbine, that much coal does not need to be burned. Fairly simple logic!

Your writer bemoans the fact that "Wind-factories, at best, operate at 17% of capacity, and take power from the grid the rest of the time." Well, hello – the wind doesn't blow all the time! The 17% figure (which may or may not be right) is the proportion of time that the generator would have to run at its full rated output, if the wind speed was sufficient for it to do so, which of course for much of the time, it isn't!

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The one point that your correspondent raises that I can readily agree with is that some wind turbines do in fact consume power from the grid when not operating! A quick look on the community-owned Hepburn Wind (Vic.) website reveals just how right "name withheld" is – for the month of July 2013, the site 'only' generated 1069.7MWh of extreme-green power but consumed a whole 2.2MWh of brown-coal produced power!

By my reckoning, for every scoop of coal burned to provide power to Hepburn Wind's turbines during periods of insufficient wind, almost 500 scoops of coal are not required when the wind is blowing!

Maurice Wedlake,
Buronga, NSW.

Wind farms can never provide base-load power

With regard to recent discussion on wind farms, SILICON CHIP readers may be interested in a recent paper of mine (Miskelly 2012) on the effectiveness of these installations.

In proposing any form of generation to replace the present CO_2-emitting sources, it is essential that it be fit-for-purpose. Can the proposed generation provide sufficient power to meet the minimum requirements? Can it always provide power at times of peak demand? Can it reliably provide the required load. If it is variable, how much backup is needed from more conventional sources?

Whether or not the proposed form of generation has the potential to reduce greenhouse gas emissions does not remove the need for rigorous evaluation. Indeed, such an evaluation is a critical

Listening to DRM may require a licence

I found the article on DRM radio in the November 2013 issue both interesting and informative. I believe, however, that the article omitted one item that some people might find significant. At present to receive DRM requires the purchase of a licence from the DRM consortium. At least that was the situation when I activated the DRM mode on my WinRadio Excalibur G31DDC radio (reviewed in the June 2012 issue of SILICON CHIP) early this year.

My experience of DRM has been disappointing. I have completely failed to find any stations at all to date but your article has given me a couple of reasons why this could be. Radio Australia, which is the station I would be most likely to pick up, only broadcasts on DRM for a couple of hours in the middle of the day. My listening is normally in the evening when SW reception is at its best. The other possibility which your article has pointed me to is the antenna. Due to some difficulties in installing a long-wire antenna on my quarter acre block I have opted to use an active antenna on my roof.

Thanks for an always interesting magazine.

Syd Read,
Hastings, Vic.

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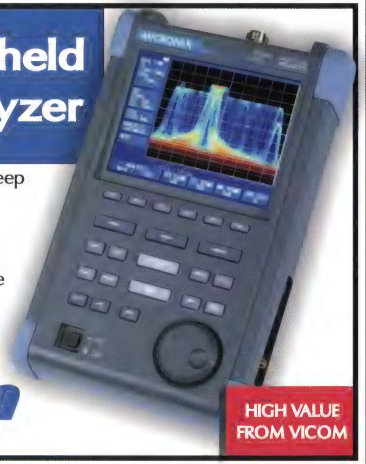

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Alternative to solid fuel nuclear reactors

I see that there has been recent discussion in the pages of SILICON CHIP about nuclear power and I agree that to make a dent in carbon dioxide emissions we should be heading down the nuclear path but there is an alternative to a uranium oxide solid-fuel reactor.

This is a molten-salt reactor using the thorium fuel cycle with a fluoride-based molten salt, running at atmospheric pressure. It has all the advantages and not many disadvantages when it comes to waste products (both fission products and transuranic products).

The molten-salt reactor can not only be used to provide energy (which can produce electricity, treat water etc) but nuclear waste from solid-fuel reactors can be reprocessed and used in the fuel cycle of the thorium reactor, thus getting rid of the nuclear waste that is around now.

A molten-salt reactor was up and running in America in the 1950s. The program ran until the early 1970s when it was terminated by Richard Nixon (I think) because he wanted more jobs in California working on the fast-breeder plutonium reactors. Also, the military wanted to go down the plutonium route because they needed this to make bombs!

Here are some advantages of the thorium molten-salt reactors:

- Uses thorium, a very common element.
- Runs at atmospheric pressure.
- Because of the above, they can be made small.
- Needs NO human input to shut down in an emergency.
- Can be installed anywhere (no water is needed).
- Next to no waste.
- Radioactive isotopes for medical purposes can be extracted while the reactor is running.

More information can be obtained at http://thoriumremix.com/th/ and http://thoriumenergyalliance.com/index.html

Greg Gifford,
Laguna, NSW.

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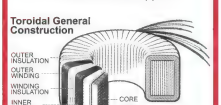

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requirement if we are to achieve the required radical emissions reductions.

First, some basic facts:

(1)The base load on the eastern Australian grid is a minimum of some 17,000MW which must be satisfied, 24 hours per day, 7 days per week, 365 days per year. The demand varies up to over 30,000MW on certain days and at various times of the year. The 17,000MW minimum is that required in the "wee small hours" of the morning after such loads as the last trains to run and off-peak hot water systems have switched off. This minimum demand represents the cumulative total of such essential services as street-lighting in our cities and towns, the provision of building security lighting, hospital round-the-clock emergency services and so on.

(2) The electricity grid operates continuously and supply and demand must be in strict balance, second-by-second. Failure to supply the demand will swiftly result in widespread blackouts. Restoration of supply after a blackout may take many hours, so permitting a blackout at any time is not an option.

(3) As a consequence, any variation in output of any generator on the grid must be immediately backed up from other generation.

At present, there is some 2500MW of installed wind farm capacity connected to the eastern Australian grid. These wind farms are scattered over a wide area of this grid. In fact, the eastern Australian grid is geographically the most dispersed on the planet, stretching from Queensland in the north and taking in the eastern states of NSW, Victoria and Tasmania, plus South Australia.

According to the wind industry and its academic supporters, wind farms have a capacity factor of some 30% and that because "the wind is always blowing somewhere", the combined output varies relatively smoothly so that, with the help of a small amount of fast-acting gas turbine backup, the wind farm fleet will easily substitute for coal-fired and other nasty polluting forms of generation to provide the all-important base load requirement.

Close inspection of actual operational data shows that sadly, wind farm performance falls far short of this ideal. Furthermore, little can be done to improve the outcome. I have conducted an analysis of wind farm operational data for the full calendar year 2010. It shows the following:

While the 30% figure is often met and indeed exceeded, what is never mentioned is that for some 70% of the total time, wind farm output is less than 10% of the installed capacity, that the average value of 30% installed capacity is met, invariably, by the wind farm producing short bursts at up to 100% installed capacity during the remaining 30% of the time. The consequence is that the output is extremely erratic, extremely variable and almost totally unpredictable.

The fact that the output varies right across almost the full range means that the required fast-acting (gas-fired) backup has to be nearly equal to the full installed capacity. In fact, it has to

be some 80% of the installed 2500MW capacity, ie, 2000MW, instantly available at all times to meet sudden drops in wind output.

During calendar year 2010, wind farm output dropped to nearly zero on 109 occasions. Even one such dropout in a proposed system of generation desired to replace fossil-fueled plant is unacceptable, but to countenance over 100 such occurrences per year is a totally preposterous and totally irresponsible proposal.

This "common mode" failure has nothing to do with reliability of the wind farms. Instead, it is due entirely to weather systems: large high pressure systems frequently occupy the full extent of the eastern Australian grid, with the result that there is virtually no wind anywhere. So even though many more wind farms might be built within the region of the eastern Australian grid, the widespread lack of wind during these high pressure weather systems would still result in minimal output.

Naturally, as the wind fleet increases the size of the needed back-up also increases. The increased swings in wind output cause grid management to become ever more difficult, adding to the instability concerns. Indeed, we learned recently that Snowy Hydro is being drafted into this whole sorry mess; the generators on the Upper Murray are being used to ramp up and down so frequently in attempting to compensate for the wind's variability that massive erosion of the Murray's banks, resulting from the wild flow fluctuations, is causing a significant loss of valuable farmland (ABC Stateline-NSW: www.abc.net.au/news/video/2013/04/05/3731094.htm)

Because the output of this large wind farm fleet is so highly variable and unpredictable, there is no useful match to the grid operational requirements whatsoever (see Miskelly P, 2013) for the full details

As to the extent of the emissions reductions, I refer readers to Inhaber (2011). This careful study shows that where wind penetration reaches or exceeds 20% of the total installed generation capacity on an otherwise fossil-fired grid, because of the need to back-up wind's intermittency, the net CO_2 offset is negligible.

Many wish to believe that wind and solar can fully supply our energy needs and that "nasty" coal is easily replaced by "wonderful renewable technologies". Wind's colossal failure can no longer be hidden by such wishful thinking.

Proposing a technology such as wind energy that requires massive amounts of energy storage on the basis that such technologies are "just around the corner" is pointless. Peter Lang (Brook 2009) has provided the costings for energy storage – they are huge. Remember, that minimum base load requirement of 17,000MW MUST be met at all times.

"Smart metering" will not solve that problem. It may provide a means of smoothing the daily peak demand but will not reduce the all-important essential services demand requirement.

Paul Miskelly,
Mittagong, NSW.

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Amid the ear-shattering scream of superbikes hurtling down Brabham Straight at around 280km/h came a couple of rather special bikes doing not *much* less speed . . . but significantly less decibels! In fact, compared to the rest, it was almost silent – just the whoosh of the wind, a bit of chain noise and the (albeit minimal!) tyres-on-tarmac note.

We were at **Sydney Motorsport Park** (aka Eastern Creek) to witness practice day for the round of superbike racing on the following two days. And while the petrol superbikes were rather impressive, that's not what we were there to see.

Instead, we had been invited to watch purely electric-powered bikes put through their paces by a couple of Australia's leading electric motorcycle racing exponents, as part of the Electric Formula Extreme Challenge.

Danny Ripperton had his own Ripperton bike while Jason Morris was aboard a bike from Varley. They're perhaps better known for the electric tugs used to pull jumbo jets around airports!

But let's wind the clock back a few weeks and tell you how all this came about.

Knowing of our interest in electric vehicles, we were approached by the promoter of the 2013 Electric Superbike series, Victor Fenech. Victor was producing a series of TV programs for the free-to-air community television station TVS and wanted to know if SILICON CHIP was interested in also promoting the electric superbike concept.

Hence this feature!

We received a considerable amount of feedback from readers when we featured the all-electric Nissan Leaf car (August 2012) and the all-electric Vectrix motorcycle (May 2008).

While some readers were quite critical of the concept of electric vehicles the vast majority were most interested in the technology and the way it had advanced in recent times.

Therefore we were sure our readers would also be interested in the concept of electric superbikes. Who knows, some of it might be a vicarious desire to be screaming down the straight at more than 200km/h!

What's it like?

The electric superbike is not too dissimilar to those petrol-powered speed demons you've seen fanging

By Ross Tester

around Eastern Creek or Philip Island (and other racetracks, both here and overseas).

In fact, we'd already heard about the electric superbikes' prowess from their involvement in the Isle of Man Classic race, earlier in the year. In that race, an electric superbike ***averaged*** speeds greater than 160km/h.

But what makes the electric bike quite different is, of course, that there is not even a nanolitre of petrol involved, nor is there any internal combustion.

They are not hybrids – in the case of the Ripperton bike (the red "No46" above) they derive 100% of their power from not one but two "tandem" high performance, water-cooled 175V electric motors, each rated at 50hp. Both motors drive the one shaft; the bottom motor has a sprocket and chain to drive the rear wheel in a somewhat conventional way.

It's only somewhat conventional because there is no gearbox or clutch. As you would no doubt realise, an electric motor delivers its maximum torque at zero rpm, so there's little need to go "up through the gears" to deliver maximum power when you need it.

Unlike fuel-powered bikes, the electric-powered model has what amounts to a "reverse gear" – very handy for manoeuvring around the often limited confines of the pits and garage behind. It's not a true reverse gear – it's simply a switch which swaps two of the three motor wires and makes them turn backwards!

A three-phase controller handles delivery of power to the motors, dependent (of course!) on the amount of "throttle" applied by the rider. Motor speed is monitored by a Hall Effect sensor on the main motor (the second motor, by definition, must be rotating at the same speed).

The controller is fan-cooled but also relies (as does a lot of other cooling) on the not inconsiderable cooling power of a 200km/h airstream!

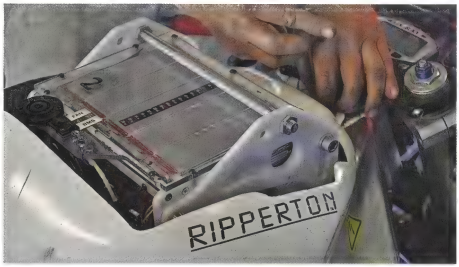
The motors are driven from a stack of 42 very-carefully-managed Lithium Polymer cells. On board the bike is a range of engine and battery management technology which is available for analysis after the race to ensure optimum "tuning" next time out.

Safety is vitally important in electric superbike racing: here you can see the "big red button" which cuts off all power to the bike (underside) along with the large red light on top which tells everyone the bike is powered. There's no screaming motor to warn you!

The entire battery pack is removable from the bike – it is charged outside the bike. Each cell is individually monitored during the charging process, with a shunt resistor across the cell being brought into play if the cell voltage exceeds the 4.15V intended charge.

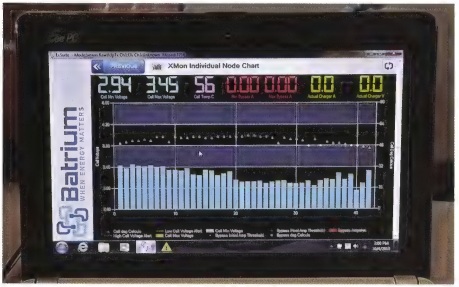
The battery pack weigha about 55kg and measures around 750mm high x 250mm wide x 220 deep and sits basically under the rider and in the bike frame, much where you'd expect

Here Victor Fenech, resplendent in his "Silicon Chip" yellow shirt, is interviewing two of the leading movers and shakers in the electric superbike world for the TV show he's producing: at left is Varley rider Jason Morris and in the centre, Danny Ripperton.



The 42-cell Lithium Polymer powerhouse sits vertically in a specially-designed cradle underneath the rider's seat. Extensive on-bike electronics monitors the cell charge levels, temperature, loading, etc.

At 55kg, getting the battery pack out is no mean feat – and virtually impossible from alongside the bike. Here Danny Ripperton stands on the supported bike to extract the 750mm-deep pack.



Batteries are charged outside the bike with every cell monitored. A dedicated computer gives instant feedback via "Batrium EV Suite" software.

to find the fuel tank and engine on a "normal" superbike.

However, the shape of the battery pack and motors means that a conventional bike frame is unsuitable for electric power, so many iterations of frame have been produced to find one that gives that miniscule increase in performance over other types. When your lap times are measured in thousands of a second, any advantage you can obtain is an advantage you DO obtain!

Just as a fuel tank on a petrol bike only holds a certain amount of energy, so do the batteries. They typically last about 5-7 laps around Eastern Creek, although after four laps they're getting pretty hot. Again, battery temperature is one of the parameters that's carefully monitored.

Only rechargeable batteries can be used – one-time batteries could achieve better results but these are not permitted under race rules. Interestingly, the rules do permit more than one driven wheel (eg, using in-wheel motors) but so far, no bikes have been entered with more than one wheel driven. Yet!

Race rules say that the bike needs to be able to complete 18+ kilometres at race speeds, including the warm-up lap (the warm-up lap is not so much to warm the engine, as it is for petrol bikes, it's to get the rider used to the bike at race speeds and heat the tyres – which of course petrol bikes need too).

The day we went to Eastern Creek, the first run of the Ripperton electric bike, being ridden by Australian Champion Kevin Curtin, achieved less than two laps and ignominiously returned to the pits on the back of a recovery vehicle.

The pit crew spotted the problem in an instant: the power lead which plugs into the battery pack had somehow vibrated loose and off. No power = bike stops!

Later, the Varley bike, ridden by Jason Morris, also impressed us on the track.

Safety

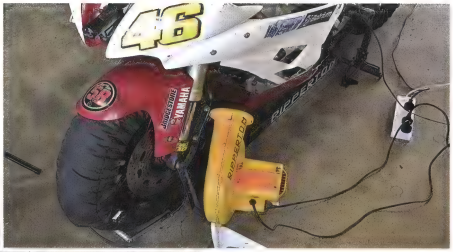
While a bike is out on the track, another battery pack (or packs) are usually charging in the garage behind the pits. It is mandatory for a competent team member to be present and monitoring the charging process.

At Eastern Creek, we were able to see the charging and monitoring

process with all cells being analysed and displayed in real-time via a laptop computer. On the Varley bike the batteries are not removable: they're chaged "in situ"

The Battery Management System is a vital and compulsory component as batteries could present a risk of overheating and fire. The BMS must provide a feedback loop to the charging system to disable charging in the event that a cell or cells exceeds the charge voltage limit specified by the cell manufacturer.

It must also be capable of disconnecting power if the overall pack voltage is greater than (or less than) the cell manufacturer's specifications.



Like all racing bikes, off the track the tyres must be kept warm for maximum adhesion. At the same time the motors, batteries and electronics must be kept cool. Here a powered tyre heater sits alongside a blower fan – one heating, one cooling!

The Battery Management System and other monitoring circuitry takes a fair amount of space (and adds weight) on the electric superbike. Weight must be kept to a minimum to remain competitive.

The BMS is also (usually) the component responsible for regenerative braking – that is, recovering energy from the momentum of the bike under braking, picking it up from the motor powering the rear wheel. However, we were told that given the short, sharp braking typical of racing circuits, the amount of energy that can be reclaimed is miniscule.

The conventional (hydraulic) brake is on the front wheel only.

The rules state that voltage is limited to a peak of 700V between any two points. This means a maximum of 700V DC or 700V peak for AC. And in cases where the voltage of the power circuit exceeds 42V, the power circuit must be well insulated from the onboard circuitry.

There must be two emergency stops on each electric superbike. One is via a lanyard which disconnects power should the rider and bike become separated. The second is via a "big red button" on the back of the bike (immediately behind the rider) which is a mechanical switch, capable of being activated by anyone in the event of an incident.

The circuitry must be set up so that the voltage across the capacitors in the power circuit falls to 65V or less within five seconds if the general circuit power breaker is opened, or if the

Duties of a scrutineer

Malcom Faed, photographed above with Victor Fenech, is well-known to SILICON CHIP readers from his fuel-to-electric utility conversion (*SILICON CHIP, June 2009*). Malcom is an electric bikes scrutineer for the Electric Formula Extreme Challenge. Here he covers just some of his role . . .

4-6 weeks before a bike first competes, we review the TCF (compulsory Technical Construction File) documents of the machine entering the series.

Over the following week or so clarification and additional information and photos is requested from the team, or even a visit to the bike in order to understand the machines construction, technologies and implementation of the technical rules.

This gives the teams sufficient time to make any necessary modifications required by the scrutineer.

2-3 weeks before the event, each team is contacted to review any rule amendments or concerns. Any modifications to the machines are also reviewed and the TCF documents updated accordingly.

On Race Day

Arrive bright and early to the venue. (Sydney Raceway, Queensland Raceway, Wakefield Park and Winton have hosted previous events). Sign on with the organisers.

Meet the recovery crew and the ambulance crew and give a safety briefing on the measures to take should a bike be involved in an accident. This needs to occur three times over the weekend as often there are different crews each day.

Meet the teams and perform electrical scrutineering before the event. This consists of verifying that the emergency stops, horn and visual indicators are functioning and meet the rules.

During the event – 3G coverage permitting – I will update the eFXC Facebook and Twitter accounts with event information and race times in order to promote the event. There are also many people overseas keeping an eye on Australian developments.

The details for the electric Formula Xtreme Challenge (eFXC) are available www.formula-xtreme.com.au/xtrememansf/1-FrontNewsPage

Thanks to the Australian Formula Xtreme Challenge for hosting the fledgling sport of electric superbike racing along with the petrol bikes.

Over the course of the weekend notes are recorded on the scrutineering, any incidents and notes to assist the organisers in future events.

over-current sensors on the batteries are tripped.

When the bike is in a powered-on state, a flashing red light mounted on the rear bodywork and visible from at least 30m away, from both sides and rear of the machine, must be activated.

All electrical cables inside the motorcycle must be protected by means of over currents trips rated according to the diameter of the individual conductors. There are also significant rules regarding the battery mounting, insulation and even its behaviour in the event of an incident.

The entrant must ensure that the electrical components used cannot cause injury under any circumstances, either during normal operation or in foreseeable cases of malfunction.

Are they competitive?

When you look at top speeds of conventional bikes, you might think that e-bikes are not really competitive. But that's not really the case because you need to compare apples with apples.

The electric-powered bikes are on a pretty steep development curve (three years ago there was no such thing!). But already, they're managing about 205km/h or so down the long straight at Eastern Creek.

The best riders on the best 1000cc superbikes currently attain a top speed of about 280km/h. But when you look at the 450 and 600cc classes, the electric bikes really are right up there. 450cc bikes can manage 195km/h and the best 600cc with a top-notch rider can push that up to about 220km/h. So you can see that the electric bikes are well in the race when it comes to the 450 and 600cc classes.

It's the aim of people like the Ripperton and the Varley teams, some of the leaders in electric bike development, to get them up there with the big boys and they believe they are well on the way to achieving that aim.

In fact, we at SILICON CHIP are in awe of people like Ripperton and Morris – and the teams behind them – who are on the cutting edge of this technology.

As we mentioned earlier, three years ago, there was no such thing as an electric superbike but through sheer persistence and "never say die" attitude, they have developed their bikes to the point where they are today . . . and are continuing that development unabated.

What we are witnessing is the early stages of a developing racing class. But it's a class that needs more entrants. There is a real collaborative spirit in the pits and a strong interest from various groups just wanting to get involved in building a bike.

With no shortage of riders awaiting the challenge of riding an electric superbike the next step is getting more bikes on the grid.

If you are interested in getting involved, or you would like the challenge of building (or supporting the building of) a competing bike please contact Victor Fenech at victor@evmotorcycle.org

Act early and your bike could be competing in 2014! SC

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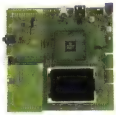

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Update your car's interior with LED lighting

LED interior lamps in this 2004 Honda Accord not only have much better colour rendition than the original incandescents but give a brighter and more even light than before.

By LEO SIMPSON

These LED lamps can be used to replace a variety of incandescent lamps in your car.

Are you hankering to replace your car even though it is still reliable and has many years of life in it? It's a common feeling but one way to at least partially cure that hankering is to make some small mods which make it look more up-to-date. Changing your car's interior lights to LEDs is an easy and cheap modification which is a really worthwhile improvement.

LET'S FACE IT; incandescent lamps are old hat and LEDs are the new way. More and more cars are now fitted with LED stop and traffic indicator lighting and some are even using high-intensity white LEDs for their headlights. But some cars which use LEDs for their headlights, such as the latest Honda Accord V6, still use boring old incandescent lamps for their interior lighting.

There are two major faults with incandescent lamps for car interior lights. First, they are often not bright enough to let you read a map and second, they pull too much current. In fact, leaving your interior lights on overnight can easily flatten your battery. Some cars have an inbuilt timer which switches off the courtesy lights if they are inadvertently left on but many don't. Back in the days when cars only had one interior light, it wasn't such a problem but many cars

have quite a few incandescent lamps and they can add up to a sizable drain on the battery.

In my 2004 Honda Accord for example, there are three lamps in the roof of the cabin and one in each door. The cabin lamps each pull about 600mA while the door lamps each pull 240mA (at 12V). Hence, if I leave one of the doors ajar, the total current drain is just over 2A which is certainly enough to flatten the battery overnight (fortunately, in the Honda Accord, the cabin lamps turn off after a delay period).

However, while the current drain is relatively high, the quality of lighting is poor and looking at them, I was always thinking that they looked so "orange" and old-fashioned. In fact, they reminded me of the headlights on 6V cars (particularly on the VW beetle) which were so feeble that you had to light a match to see if they were on!

There is another disadvantage of incandescent lamps for car lighting and that is the lamps get so hot that they can discolour and even char the diffuser. After all, a 12V 600mA lamp dissipates over 7W. Of course, as they get older, the lamps also blacken and that reduces their brightness even further. Ultimately, they die and you are left in the dark; quite disconcerting if it happens just when you want to look at a map!

Recently, one of the interior lamps in my car died and I decided to fix them once and for all. Most car interior lighting either uses double-ended "festoon" bulbs or so-called "wedge" lamps which are all-glass construction with connection wires on both sides of the glass "wedge" which pushes into a socket. Now the good news is that there are countless LED equivalents

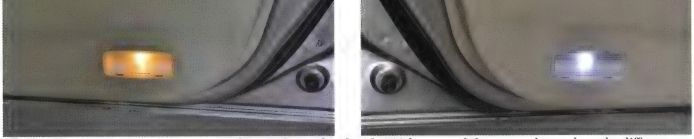
This photo clearly shows the effect of replacing the righthand front roof lamp in this 2013 Honda Accord with a wedge LED lamp. Note the colour difference between it and the original the incandescent lamp at left.

Both the front roof lamps in this 2004 Honda Accord have been replaced with LED lamps. They not only have a cool white light but are also brighter and generate considerably less heat than incandescent lamps.

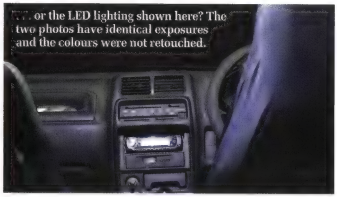
to these incandescent lamps and you can get them in a range of colours (cool white for me, thanks, and one sugar), with differing arrays of surface-mount LEDs.

Some of these are based on a small PCB with an array of four, six, eight or more LEDs and some have a more complicated construction where tiny PCBs are assembled together to give light radiation over wider angles.

Now as far as car interior lighting is concerned, these fancier shapes are unnecessary and defeat an advantage of surface-mount LEDs which radiate all their light in one direction. For



The door lamps in the 2004 Honda Accord were also updated with LED lamps and these two photos show the difference between the old at left and the new at right. The cool white of the LED lamp is not only brighter but looks far better than the orange light from the original incandescent lamp.



interior lamps, there is no need to radiate light in many directions since they will be fitted in a housing which only lets light out in one direction anyway.

Identifying the lamps

The first step in this process is to identify the particular types of lamps in your car. This can be a bit of chore as some of the diffusers can be quite tricky to remove and there is a risk that you might crack one when attempting to do so. Having removed the diffuser and the bulb, make note of its dimensions. Festoon bulbs come in various sizes, eg, 31mm, 39mm and 42mm long etc, and it is important that your LED replacements fit properly.

The same comment applies to wedge lamps – they also come in different wedge sizes.

Armed with the type and size details, you are ready to start shopping. Now you will find vast numbers of LEDs and sellers on the internet and undoubtedly many of them are cheap and entirely satisfactory. I purchased a number of different types on the internet but I also visited my friendly local Jaycar store to make sure that I purchased the correct wedge lamps for the doors in my car. I wanted to check that I could buy the exact replacements because many of the LED lamp illustrations on the net do not really show the key dimensions. So you could buy them and then find they simply don't fit.

In my case, Jaycar had the correct-sized wedge lamps (Cat. ZD-0390) I needed for the doors of my Honda Accord. And while Jaycar also have a fine selection of festoon style and other lamps for car lighting, including those for brake and reversing lights, I had already obtained a selection of festoon lamps from on-line sellers on the net.

While you have to obtain festoon lamps with the correct overall length, you will also find they are mostly based on a single PCB with an array of six, eight or in one case that we found, 24 SMD LEDs. Be aware that these PCBs can be much wider than the original festoon bulbs and if they are too wide for the particular housing in your car, they simply won't fit.

Nor should you make the mistake of thinking that you should simply fit the brightest LED lamps you can get. There is no point in them being needlessly bright. After all, they are at close range and you don't want to be blinded.

Depending on which LED lamps you choose, their current drain will be a great deal less than the original incandescent lamps. For example, compared with the festoon lamp's 600mA @ 12V (800mA @ 14.4V), the LED equivalents I fitted with six SMD LEDs each only pulled 36mA. So I managed to reduce the total current when a door is left ajar from over 2A to just over 120mA. That's about one seventeenth!

An incandescent wedge lamp (left) and its LED replacement lamp at right.

By the way, there are no polarity markings on the LED lamps. It's just a matter of trial and error to determine which way around they go and there's no damage done if you get it wrong.

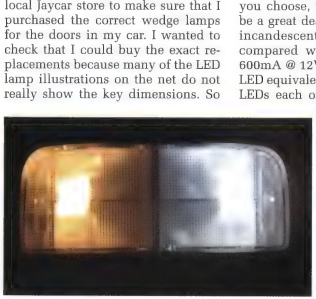
Colour variations

Another point to consider is that even though you might purchase a batch of LED lamps on the internet for a bargain price, they will not all necessarily be the same colour. We found some that were not well matched within the same batch. You certainly don't want LEDs of slightly different colour in your car, as it can look quite odd.

And while I prefer cool white LEDs, other people may prefer warm white. I just think that warm white is a poor imitation of the same sickly colour as incandescents. It certainly does not provide better colour rendering; most LED lamps are poor in this respect.

There is really not much more to say on this topic. The photos accompanying this article show how effective LED lamps are at lighting your car's interior. They certainly do improve the look of the cabin at night and they should last for the life of the car.

Finally, the total current drain of the interior lamps will be drastically reduced, meaning that you could leave them on for several days without flattening the battery. SC



This rear interior ceiling light in a 2013 Honda Accord has been fitted with a LED lamp on the righthand side only. Once again, the difference in colour temperature compared to the incandescent lamp on the left is obvious.

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Electronic Bellbird

By JOHN CLARKE

Photo by Sascha Wenninger – http://www.flickr.com/photos/sufw/9055617579/

Looking for a great school project or a really unique Christmas decoration? This electronic Bellbird mimics the musical bell-like sounds of a real Bellbird (or Bell Miner) and has a dynamic LED chaser display as well.

Bellbirds

And, softer than slumber, and sweeter than singing,
The notes of the bell-birds are running and ringing.
The silver-voiced bell-birds, the darlings of daytime!
They sing in September their songs of the May-time;
from "Bellbirds",
by Henry Kendall

KNOWN FOR their characteristic tinkling bell sounds, the Bellbird (or more correctly the "Bell Miner") lives amongst the eucalyptus tree canopies in South-Eastern Australia. But while the bell-like sounds they make are very musical, their presence is not always completely appreciated. Intrigued? – check out the "Bell Miners & Dieback In Native Trees" panel for more information on this.

By contrast, the SILICON CHIP Bellbird, which mimics the sound of a real bellbird, will always be appreciated. It's presented here as a stand-alone bell-shaped PCB with eye-catching LED lighting effects and a piezo transducer for the sound output. A 3V lithium cell powers the unit which can be hung on a hook or nail on a wall, or even attached to a Christmas tree.

Like the real Bellbird, this electronic Bellbird only make sounds during the day or when there is sufficient ambient light. And like the real Bellbird, the sounds it produces are sets of bell sounds with randomised spacings and repetitions. This randomisation

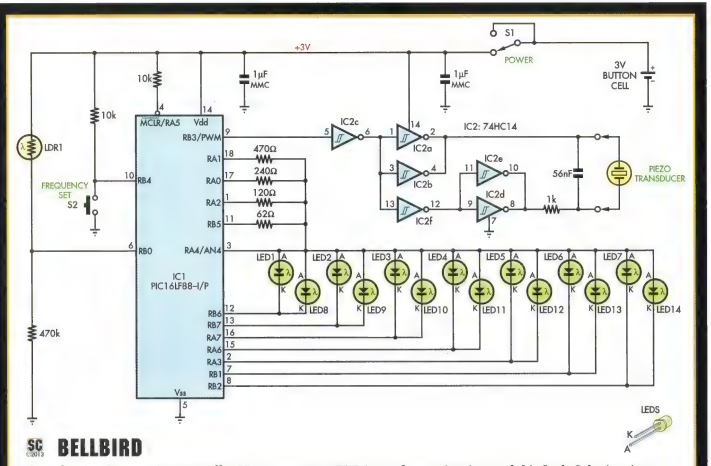

Fig.1: the circuit uses microcontroller IC1 to generate a PWM waveform at its pin 9 and this feeds Schmitt trigger inverters IC2a-IC2f which in turn provide complementary (push-pull) drive to a piezo transducer. IC1 also drives LEDs1-14 which are arranged in seven paralleled pairs to provide a chaser effect around the outside of the bell.

prevents the bell tones from sounding as though they are electronically generated. A power switch at the top of the PCB allows the unit to be switched off if necessary.

As well as producing realistic bell sounds, the unit drives 14 LEDs which are arranged around the periphery of the PCB. Whenever it produces a bell sound, these LEDs chase downwards on either side of the bell and then along the base to the centre. The six LEDs along the base then chase from the centre to either side and then back to the centre again, to simulate the final "ringing" of the bell.

So unlike a real Bellbird which is difficult to spot amongst the forest canopy, our unit is highly visible. It makes a great novelty project and is ideal as a Christmas decoration.

Circuit details

Refer now to Fig.1 for the circuit of the Bellbird. There's not much to it – just two ICs, 14 LEDs, an LDR and a few sundry bits. A piezo transducer reproduces the Bellbird sounds.

Inevitably, one of the ICs is a microcontroller (IC1). This is programmed to produce the Bellbird sounds via its pulse width modulation (PWM) output at pin 9. Twelve other outputs of IC1 are used to drive the LEDs.

The PWM output is set to run at around 2.8kHz with some variation and its duty cycle is varied to alter the volume. With a 50% duty cycle, the volume is at its maximum and as the duty cycle is reduced, the volume falls. The duty cycle ranges from 50% down to zero, with the minimum volume set at 0.2%.

Features & Specifications

Features

- Unit produces lifelike Bellbird sounds
- Bell-shaped PCB with LED chaser around outside; LEDs chase on bell sounds
- Constant LED brightness as cell voltage varies
- Bellbird sounds cease in darkness and low ambient light levels
- Low current drain plus power on/off switch

Specifications

Power supply: 3V lithium cell

Current drain: zero when switched off, <1µA in darkness (100nA measured), typically 1.3mA average in light.

Cell life: 180 days expected with one hour per day usage

Bellbird tone: adjustable over a ±12% range in 0.375% steps

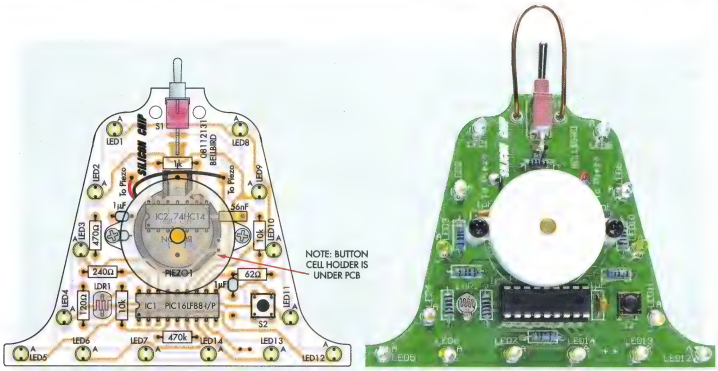

Fig.2: follow this parts layout diagram to assemble the parts onto the bell-shaped PCB. The piezo transducer is mounted on M3 x 9mm Nylon spacers, while the button cell holder is mounted on the back of the PCB (see photo). Note that it's a good idea to mount the LEDs 5mm proud of the board so that they aren't obscured by other parts.

The piezo transducer is driven via IC2, a CMOS hex Schmitt trigger. IC2c buffers and inverts the PWM output from IC1, while paralleled stages IC2a & IC2b re-invert the resulting signal to drive the top of the piezo transducer.

IC2f also inverts the signal from IC2c. Its pin 12 output in turn drives IC2d & IC2e so that their outputs are inverted compared to those from IC2a & IC2b. This allows the piezo transducer to be driven in complementary fashion with a nominal 6V peak-to-peak.

Basically, when IC2a & IC2b's outputs are at 3V, IC2d & IC2e's outputs are at 0V and vice versa. Because the two sets of outputs alternatively swing to 3V, this gives a 6V peak-to-peak drive (actually >5V peak-to-peak) for the piezo transducer.

In effect, this doubles the output voltage drive compared to just using the PWM signal from IC1 as a single output, with the second terminal of the transducer connected to ground. That arrangement would provide a peak signal of less than 3V to the piezo transducer.

Note that IC2d & IC2e drive the lower piezo transducer connection via a filter consisting of a 1kΩ resistor and 56nF capacitor. This filter rolls off the response above 2.8kHz and thus removes the harmonics from the square-wave outputs of the Schmitt triggers. In effect, it ensures that a "cleaner" sinewave signal is fed to the piezo transducer.

LED chaser

LEDs 1-14 are driven by IC1 as seven sets of paralleled pairs. In practice, they are arranged on the bell-shaped PCB to give symmetrical lighting either side of centre. For example, LED1 is positioned at the top left of the PCB while its paralleled twin LED8 is positioned at top right.

As shown on Fig.1, the LED anodes are commoned and driven by IC1's RA1, RA0, RA2 & RB5 outputs via resistors. By contrast, each LED pair is driven independently via the cathodes, with LED1 & LED8 lighting when IC1's RB6 output goes low and switching off when this output goes high. Similarly, LED2 & LED9 light when RB7 is low, LED3 & LED10 light when RA7 is low and so on.

The 470Ω, 240Ω, 120Ω & 62Ω resistors can be individually driven by IC1

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
56nF	0.056µF	56n	563

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
2	10kΩ	brown black orange brown	brown black black red brown
1	1kΩ	brown black red brown	brown black black brown brown
1	470Ω	yellow violet brown brown	yellow violet black black brown
1	240Ω	red yellow brown brown	red yellow black black brown
1	120Ω	brown red brown brown	brown red black black brown
1	62Ω	blue red black brown	blue red black gold brown

Bell Miners & Dieback In Native Trees

The Bell Miner (Manorina melanophrys), commonly known as the Bellbird, is found in the eucalyptus forests of south-east Australia. The birds feed mainly on dome-shaped protective coverings made by a particular psyllid bug from its own secretions. These bugs themselves feed on the eucalyptus from the leaves of eucalyptus or gum trees.

Colonies of Bell Miners allow large populations of the psyllid bug to exist in their territory by expelling other birds that also eat these bugs. They also maintain a sufficiently large territory so that they don't over-feed. This maintains the population of psyllid bugs and can lead to 'die back' in the eucalyptus forest.

or driven in various parallel combinations to power the LEDs. This allows the LED current to be maintained at a relatively constant value as the supply voltage progressively drops from 3V when the cell is new down to 2V as cell discharges.

The voltage across the lit LEDs always remains close to 1.8V which leaves 1.2V across the resistors when the button cell is at 3V and just 0.2V across the resistors when the cell is down to 2V. By selecting the appropriate resistance, we can set the LED current to about 5mA regardless of cell voltage.

In operation, each resistor is effectively switched into circuit when its corresponding pin on microcontroller IC1 is set high. Alternatively, a pin can be set as an input to effectively disconnect its resistor and thus prevent it from contributing to the LED drive.

For example, when RA1 is high, the LEDs can be driven via this 470Ω resistor. Alternatively, when RA1 is set as an input, this resistor does not contribute to any LED current. Similarly, when RA0 is high, it drives the LEDs via the 240Ω resistor and so on.

If more than one output is set high, the corresponding resistors are driven in parallel. Taking them all high provides the lowest resistance possible (since that are effectively connected in parallel) and this is required when the cell voltage is down to 2V.

When the cell voltage is 3.0V, just the 240Ω resistor drives the LEDs. For any voltage between 2V and 3V, a suitable combination of resistors is selected so that the LED current is always close to 5mA.

Determining cell voltage

So how does IC1 measure the cell voltage so that the appropriate resistors can be selected? It's done by using the AN4 input to measure the voltage between the anodes of LEDs1 & 8 and the positive supply when these LEDs are driven via the 470Ω resistor at RA1.

In practice, the voltage across the LEDs remains close to 1.8V regardless of the variation in LED current and so the measured voltage is proportional to the supply (ie the cell voltage). As previously stated, at 3.0V the voltage measurement is 3.0 - 1.8V = 1.2V. With a 2V supply, the voltage measurement is 2 - 1.8V = 0.2V, and so on.

A look-up table in the software specifies which resistors should be selected for a given measured voltage.

LDR1 is used to monitor the ambient light, so that the LEDs only come on during daylight or in high ambient light conditions. This is done to conserve the cell and works as follows.

In darkness, the LDR's resistance is very high at several megohms and so pin 6 of IC1 is held low (1V or less) via its associated 470kΩ resistor. When IC1 detects this low voltage, it goes to sleep, stopping all operation and thus minimising the current drain from the cell. Typically, the current drain in this sleep state will be less than 1μA but our prototype was measured at just 100nA.

As soon as light is received by the LDR, its resistance falls to around 10kΩ and the voltage at pin 6 rises to almost the supply voltage. This causes the microcontroller to wake up and begin playing the Bellbird tones and driving the LEDs. Note that IC1 always checks the cell voltage each

Parts List

1 double-sided plated-through PCB, code 08112131, 91 x 73mm (bell shaped)
1 PCB-mount SPDT toggle switch (Altronics S1421 or equivalent) (S1)
1 SPST vertical mount micro-switch with 6mm actuator (Jaycar SP-0603, Altronics S1421) (S2)
1 20mm button cell holder (Jaycar PH-9238, Altronics S5056)
1 CR2032 lithium cell
1 30mm diameter piezo transducer (Jaycar AB-2440, Altronics S 6140)
1 LDR 10kΩ light resistance (Jaycar RD-3480, Altronics Z1621) (LDR1)
2 M3 x 9mm tapped Nylon spacers
4 M3 x 5mm screws
1 70mm length of 1.25mm enamelled copper wire

Semiconductors

1 PIC16LF88-I/P microcontroller programmed with 0811213A.hex (IC1)
1 74HC14 DIP14 hex Schmitt trigger (IC2)
1 DIL14 IC socket
1 DIL18 IC socket
14 3mm green high brightness LEDs (LED1-14)

Capacitors

2 1μF monolithic ceramic (MMC)
1 56nF or 47nF MKT polyester

Resistors (0.25W 1%)

1 470kΩ	1 240Ω
2 10kΩ	1 120Ω
1 1kΩ	1 62Ω
1 470Ω	

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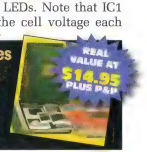

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Can It Be Made Louder?

Inevitably, some people will want to make it louder and will want to know what modifications are necessary to achieve this. Hence, after the circuit had been fine-tuned to give the most realistic Bellbird sounds, we looked at whether the low-pass filter in series with the piezoelectric transducer could be further tweaked to make it louder.

To that end, we reduced the 1kΩ current-limiting resistor to 220Ω and increased the associated filter capacitor from 56nF to 220nF (the piezo transducer has a self-capacitance of 38nF).

The result was that it was slightly louder but we judged that the sound was a little more "clicky" (because of the stepped modulation) and had also lost some of the subtle echo effects which make the Bellbird sound much more realistic.

Another way of making the sound louder would be to increase the supply voltage to 4.5V by substituting a 3 x AAA cell (alkaline) battery instead of the 3V button cell. Note that this will increase the peak signal voltage to about 7.5V.

Well, can the signal be fed to an external amplifier? The answer is yes but be aware that the signal has quite a wide dynamic range and the peak signal amplitude with a fresh 3V cell will be be in excess of 5V (or 7.5V peak with a 4.5V supply), so if the volume control is too advanced, the amplifier and perhaps the loudspeaker will be overloaded.

time it wakes up or when the circuit is powered up (via S1), so that it can correctly set the LED current.

Adjusting the tone

Switch S2 is used to adjust the Bellbird frequency (or tone). This is included because IC1 utilises an internal oscillator that runs with an initial 2% tolerance. As a result, the oscillator frequency may need adjusting slightly to give the correct bellbird sound.

When S2 is pressed, the resulting low on RB4 is detected by IC1 and the program then produces a series of bell tones, with each tone varying by a small amount (0.375%) for each step. The switch is simply released when the required tone is found. IC1 then stores this tone setting in its EEPROM so that the correct tone is used from then on, even if the power is switched off and on again.

If necessary, you can return to the initial default tone by pressing and holding down S2 as the Bellbird is powered up with S1. Alternatively, you can cycle through the available tones by holding S2 down until the centre frequency is reached. Since there are 64 separate tones produced, the centre tone frequency occurs 32 tones after the transition from maximum to minimum, a tone step that's readily noticed.

S1 is the power on/off switch. The 3V supply is decoupled using a 1µF capacitor for IC1 and another 1µF capacitor for IC2. The MCLR-bar pin of IC1 is a power-on reset input and pulling it high via a 10kΩ resistor ensures that the microcontroller starts correctly (ie, at the beginning of its program) when power is applied.

Note that no reverse polarity protection is included to protect the ICs against incorrect supply polarity. That's because the cell holder itself does not make a connection to the cell if the latter is inserted incorrectly. Provided the cell holder is installed on the PCB correctly and IC1 & IC2 are both orientated correctly, the circuit cannot be damaged by an incorrectly installed cell.

That said, we recommend that the supply polarity delivered by the cell in its holder be checked before installing IC1 & IC2 into their sockets. This is detailed later under testing.

This view shows how the cell holder is mounted on the rear of the PCB. It must be installed before mounting the piezo transducer, so that you can solder its leads.

Assembly

Building this project is easy and should take you no more than 45 minutes. There are no surface-mount parts (SMDs) and all parts are installed on a PCB coded 08112131 and measuring 91 x 73mm overall. This is bell-shaped and will already be cut to shape if you ordered the PCB from the Silicon Chip Online Shop or as part of a kit.

Fig.2 shows the parts layout diagram. As can be seen, all parts mount on the top of the PCB except for the cell holder which mounts on the back.

Begin the assembly by installing the resistors. Table 1 shows the colour codes but we also recommend using a digital multimeter to measure each resistor, just to make sure that each is placed in its correct position. The resistors must be pushed all the way down onto the PCB, with the leads soldered and trimmed short on the back.

The IC sockets are next on the list but make sure they are orientated as shown on Fig.2 (ie, notched ends to the left). Don't install the ICs at this stage though; that step comes later, after some initial testing.

Follow with the capacitors and the two switches, again pushing these parts right down onto the PCB before soldering. Note that S2 will only mount with one orientation, as its pin spacings differ between adjacent sides.

The LDR can now be installed (it can go in either way around), after which you can install the LEDs. The latter must all be orientated with their longer anode leads (A) towards the top of the PCB. You can push the LEDs all the way down onto the PCB if you like but we suggest mounting them about 5mm proud of the PCB so that they aren't obscured by adjacent parts.

The best way to go about this is to push each LED down onto a 5mm-high cardboard spacer (slid between its leads) before soldering it into position. To make this process easier, the leads can be soldered on the top of the PCB.

Next on the list are two M3 x 9mm stand-offs which are used to mount the piezo transducer. Secure these to the

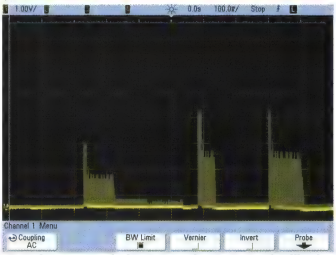

Fig.3: this scope grab shows part of a sequence of Bellbird "calls". Note that each one differs in amplitude, modulation and duration.

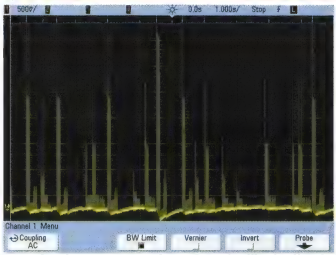

Fig.4: this shows a 10-second sequence of Bellbird calls. The scope has been over-driven to more clearly demonstrate the dynamic range of the signal which has a peak voltage of just over 5V. Again, note that there are a variety of "calls", to simulate a group of Bellbirds calling in a forest.

PCB using M3 x 6mm screws but don't mount the piezo transducer at this stage. Once these are in place, install the cell holder on the rear of the PCB (ie, under IC2).

A hanging loop can now be made using a 70mm-length of 1.25mm-diameter enamelled copper wire. Cut it to length, then scrape the enamel from the ends using a sharp hobby knife before bending the wire into a loop. The wire ends can then be bent at right angles and soldered to the holes on either side of switch S1, at the top of the PCB.

Testing

Now for some initial tests before installing the ICs and the piezo transducer.

First, insert the cell into its holder, then switch the unit on using toggle switch S1. That done, check the voltage between pins 14 & 5 of IC1's socket. You should get a reading of +3V (ie, the cell voltage) on pin 14. Similarly, pin 14 of IC2 should also be at +3V with respect to pin 7 of this socket.

If this is correct, switch off and install the ICs. Make sure that both ICs are orientated correctly; ie, with the notch or pin 1 indentation at one end of each IC towards the notched end of its socket.

The piezo transducer can now be installed. It mounts onto the stand-offs after first drilling out its mounting holes to 3mm and is secured using M3 x 6mm machine screws.

Once it's in position, trim its leads to about 35mm long, strip 3mm of insulation from the wire ends and solder the leads to the pads on the PCB marked 'To Piezo'. It doesn't matter which way around you connect these leads; they can go to either PCB pad.

And that's it! You should now be greeted by musical Bellbird sounds when the unit is switched on and the LEDs should chase down the outside of the bell and along the bottom. If necessary, you can now change the Bellbird tone by pressing and holding S2 to set the Bellbird cycling through its output frequency steps. Release the switch when the required tone is heard.

If you want to return to the default frequency, switch the Bellbird off and wait a few seconds, then press and hold pushbutton switch S2 while you re-apply power. Finally, after a second or so, release S2 and the unit will again be at the default frequency. SC

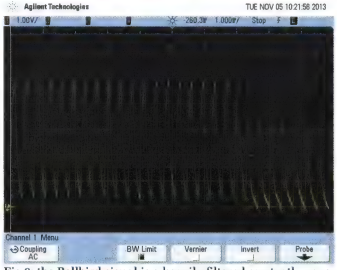

Fig.6: the Bellbird signal is a heavily filtered sawtooth waveform which is modulated in steps. The low-pass filtering has a -3dB point at about 2kHz.

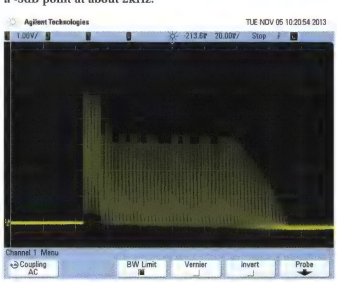

Fig.5: this scope grab shows just one Bellbird call, taken at a sweep speed of 20ms/div to show more detail of the complicated modulation which is applied to each note.

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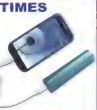

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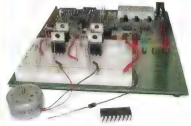

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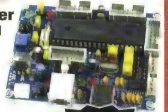

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While we have published a portable public address loudspeaker system previously (also called the PortaPAL), that was more than 10 years ago, in February 2003.

The main semiconductors used in that design have become unavailable and technology has marched ahead with efficient class-D amplifiers, along with the advent of lithium batteries which are much more energy dense.

Our new PortaPAL-D uses the CLASSiC-D Amplifier published in November and December 2012, along with its matching speaker protector from the same months and the DC-DC Converter published in May 2013.

With that combination we have a high-power amplifier that can be run from a 12V battery. One year later, we have added the preamplifiers, mixer, tone controls and power supervision necessary for the PortaPAL-D to function.

We are using two 8Ω 200mm loudspeakers (with concentric tweeters) in parallel to hand the full 100 watts available from the amplifier. Buying the commercial equivalent could easily set you back by more than a thousand dollars!

The PortaPAL-D is in a timber cabinet measuring 620 x 350 x 330mm and weighing about 20kg. It is covered in speaker carpet with corner protectors, to guard against damage from bumps and roadie use.

The two loudspeakers are mounted behind protective steel grilles that are themselves protected by being recessed into the box.

On the rear is the main control panel, again recessed into the box for protection against damage.

A top hat socket, for use with a speaker stand and a carry handle are included.

The cabinet and chassis for the electronics can be made using standard tools. And you need not be worried by small imperfections while building the cabinet since these will be covered by the carpet anyway. The result will be a PA box that looks professionally finished.

Sealed enclosure

The cabinet includes an open section to mount the PortaPAL-D electronics but the rest of the box is an infinite baffle design. This has advantages over an open-back design in that the sealed cabinet provides damping of the speaker cone at low frequencies, preventing the cone from being overdriven with high power bass signals (or when accidentally dropping a microphone onto the floor!).

Another advantage is that the microphone just needs to be positioned behind the front edge of the speaker cabinet to minimise acoustic feedback.

Two XLR sockets are provided for balanced microphones with one channel providing phantom power, if required. Both inputs can be used with dynamic microphones. Guitar input is via a standard 6.35mm jack socket while RCA stereo sockets mix left and right line inputs into a mono signal.

PortaPAL-D Features

- Class D low-distortion power amplifier delivering up to 100W to the loudspeakers
- Portable 12V Li-Po battery-powered amplifier with charger
- Twin 200mm loudspeakers with integral tweeters
- Two microphone inputs (4.5mV)
- Guitar input (50mV)
- Line input (1V) and output
- Individual level controls
- Bass and treble controls
- Standby power-down to conserve battery power
- Low battery shutdown
- Standby indication
- Charger indication
- Thermostat-operated air circulation fan
- Rugged cabinet with carpet, corner protectors and speaker grilles
- Top hat included for use with speaker stands

Each input has its own level control and bass and treble tone controls are provided.

A line output is also provided to feed an additional amplifier, recorder, etc.

Power source & management

The PortaPAL-D is powered via a 12V Lithium Polymer (Li-Po) battery rather than the sealed lead acid (SLA) type of the original PortaPAL.

This makes it much lighter. While a typical 7.2Ah SLA battery will weigh 2.55kg, the much smaller 8Ah Li-Po is less than a third of this. Plus, the Li-Po battery can be discharged much more deeply before recharging.

In effect, you get more than double the SLA's capacity for a fraction of the weight and size.

As well as a main power switch, a two-stage standby circuitry automatically powers down sections of the circuit to reduce power drain if the PortaPAL-D is not making noise. Two LED indicators show the standby status. Power is restored quickly when an input signal is detected.

A low-battery shutdown is also included which protects the battery from over-discharge. We estimate that the PortaPAL-D should run for at least eight hours with normal use and longer with periods of shutdown.

A commercially-made charger (intended for Li-Po cells) is set into the front panel, so that its controls can be accessed and its status LED visible. This can be powered from a nominal 12V (11-15V) supply, with a current up to 4.5A if the supply can deliver that.

The battery can be charged at any time, regardless of whether the PortaPAL-D is in use or even switched off.

Typically a 12V plugpack would be used to charge the PortaPAL-D, although a larger battery could also be used, either free-standing or in a vehicle.

Circuit overview

Fig.1 shows the general arrangement of the PortaPAL-D. As already mentioned, we use the CLASSiC-D amplifier module, the loudspeaker protector and the DC-DC Converter published previously. Full details for these projects can be found in the November and December 2012 issues for the amplifier and protector and the May 2013 issue for the DC-DC Converter. They can also be accessed on-line via www.siliconchip.com.au.

The CLASSiC-D amplifier is used mainly due to its efficiency (and therefore power saving). It can run at high power without generating too much heat. This is a distinct advantage

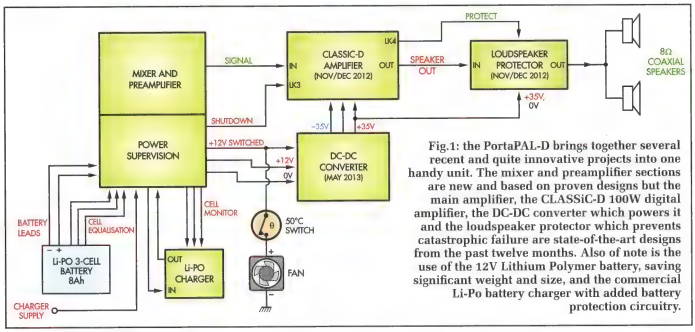


Fig.1: the PortaPAL-D brings together several recent and quite innovative projects into one handy unit. The mixer and preamplifier sections are new and based on proven designs but the main amplifier, the CLASSiC-D 100W digital amplifier, the DC-DC converter which powers it and the loudspeaker protector which prevents catastrophic failure are state-of-the-art designs from the past twelve months. Also of note is the use of the 12V Lithium Polymer battery, saving significant weight and size, and the commercial Li-Po battery charger with added battery protection circuitry.

over conventional class AB amplifiers which are nowhere near as efficient and generate significant heat.

Another reason is that the amplifier has proven reliable and has low levels of distortion and noise with extra features such as temperature cut out and over-current protection.

The CLASSiC-D amplifier is powered by a DC-DC converter, delivering plus and minus 35V DC supply from a 12V supply. With this, it can deliver up to 100W into 4Ω for short periods and 50W on a continuous basis.

A small fan is switched by a thermostat when the amplifier heatsink reaches 50°C, circulating cooling air.

Battery-saving auto shutdown

To conserve battery when not actually being driven, the PortaPAL-D has a two-stage shutdown.

First, after a short period of no signal, the amplifier module is shut down. This is controlled in part by the power supervision section. In the second stage, after a longer period of no signal, the power supervision circuitry switches off the DC-DC Converter and so powers down the system.

The power supervision circuitry also controls the charging of the battery. While power is applied, the charger continually measures the voltage of each cell, ensuring each is not over- or under-charged.

Typically, the lithium-polymer cell balancing leads would connect directly to the charger. However, this could mean the cells would discharge via the charger over time and possibly flatten the battery. To avoid this, we connect

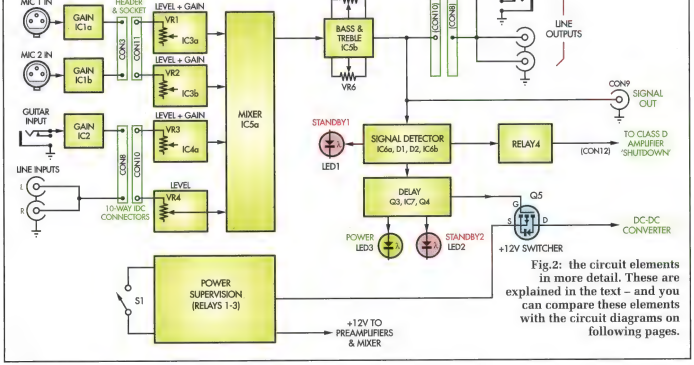


Fig.2: the circuit elements in more detail. These are explained in the text – and you can compare these elements with the circuit diagrams on following pages.

the cell monitor leads via the power supervision circuitry.

Detail of the preamplifier, mixer and standby circuitry is shown in Fig.2. Microphone inputs (Mic1 and Mic2) and their gain stages (IC1a and IC1b) are on their own PCB and connect to the main PCB via a 6-way single in line (SIL) header and socket. The guitar input and line input plus the line outputs are also on a separate PCB and similarly connect via 10-way IDC socket and plug.

The level potentiometers control the gain, with additional gain provided after the level controls for the microphone and guitar inputs. A mixer combines the four signals (Mic1, Mic2, Guitar and Line) and its output is fed to the bass and treble tone controls. From there the signal goes to the input for the CLASSiC-D amplifier, to the line outputs and also to a signal detector which forms part of the shutdown circuitry.

In "Standby 1" state, if the signal is off for longer than 15s, relay 4 is triggered, shutting down the CLASSiC-D amplifier. The amplifier is still powered but in shutdown. LED1 lights to show this state. Any input signal will instantly restore full operation to the amplifier.

If there is still no input signal af-

PortaPAL-D Specifications

Output Power:	100W into 4Ω short term 50W into 4Ω continuous
Output sound level:	Typically 96dB (SPL) at 1W
Input sensitivity and Frequency Response (-3dB):	Microphone: 4.5mV; <20Hz-20kHz Guitar: 50mV; 25Hz-25kHz Line: 1V; <20Hz-50kHz
Tone Controls:	Bass +11dB and -14dB at 100Hz Treble +9.5dB and -12.6dB at 10kHz
Signal-to-Noise Ratio:	-80dB with respect to 50W into 4Ω (inputs at minimum gain; 20Hz-20kHz bandwidth);
Muting:	Threshold at <150mW output power
Standby modes (no input):	15s typical for Standby1 100s typical for Standby2 <1s return to normal operation
Battery consumption:	"Low battery" state activated – 8.5µA Standby2 – 45mA (DC-DC converter turned off) Standby1 – 320mA (amplifier only turned off) Powered, before either standby state – 730mA
"Low Battery" thresholds:	Typically 10.5V switches PortaPAL-D off 11.2V switches PortaPAL-D on
Battery Charger:	Input 11-15VDC, 4.5A charging current maximum
Dimensions:	620 x 350 x 330mm inclusive of corner protectors
Mass:	17.5kg

Here's a view of the electronics module in its metalwork, removed from the PortaPAL-D speaker box. A commercial charger is incorporated because it is perfectly suited to the Li-Po battery pack we used and will result in longest battery life.

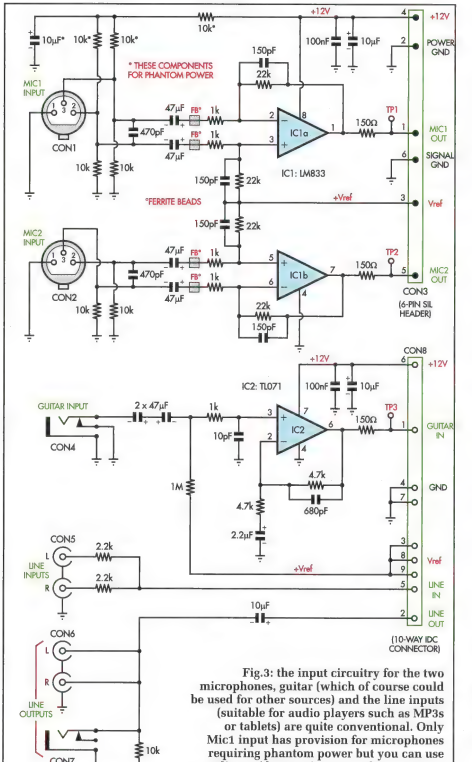
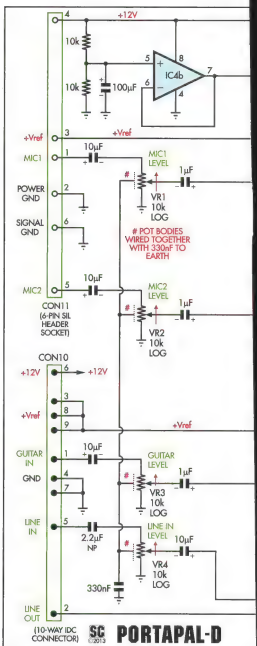


Fig.3: the input circuitry for the two microphones, guitar (which of course could be used for other sources) and the line inputs (suitable for audio players such as MP3s or tablets) are quite conventional. Only Mic1 input has provision for microphones requiring phantom power but you can use ordinary (dynamic) mics on this input too.



ter about 100s, "Standby2" state is entered. Power is switched off to the DC-DC Converter and this in turn switches off the CLASSiC-D amplifier, while LED2 lights showing Standby 2. When there is audio, power is restored to the amplifier within 1 second. LED3 lights to show power is on.

Main power is controlled via switch S1. If on, the battery voltage is monitored by the low voltage shutdown section (IC8 and Q1).

Should the battery supply drop below about 10.5V, the power to the preamplifiers and mixer is removed and the whole system shuts down. Current draw is only that of the low voltage shutdown circuitry at 8.5µA.

Circuit detail

Balanced microphone inputs for Mic1 and Mic2 are via XLR sockets, with the signals fed to the inputs of low noise op amps IC1a & IC1b. Assuming 600Ω microphones, these preamplifiers have a gain of 22. Both are identical, except that the Mic1 input provides phantom power for electret microphones (if used).

Phantom power is limited to 0.5mA or so, sufficient for the typical electret microphones used in PA systems

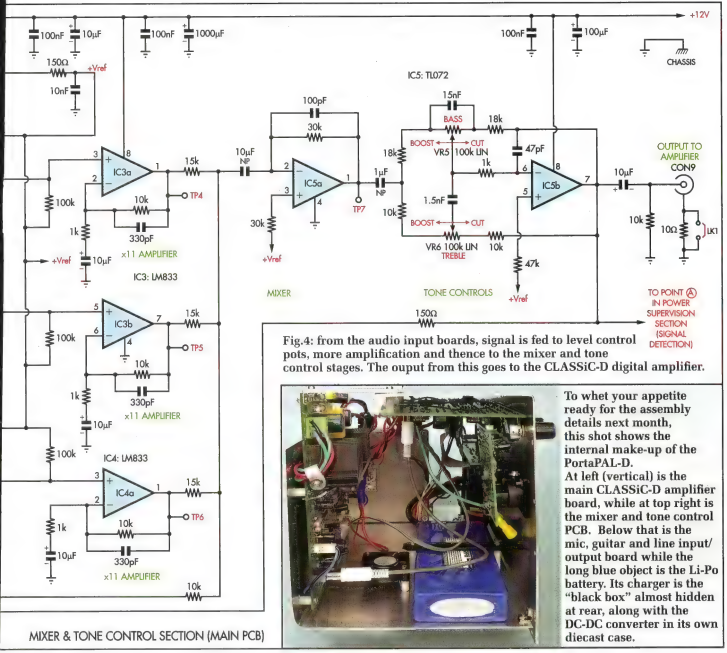


Fig.4: from the audio input boards, signal is fed to level control pots, more amplification and thence to the mixer and tone control stages. The ouput from this goes to the CLASSiC-D digital amplifier.

To whet your appetite ready for the assembly details next month, this shot shows the internal make-up of the PortaPAL-D. At left (vertical) is the main CLASSiC-D amplifier board, while at top right is the mixer and tone control PCB. Below that is the mic, guitar and line input/ output board while the long blue object is the Li-Po battery. Its charger is the "black box" almost hidden at rear, along with the DC-DC converter in its own diecast case.

but not condenser microphones. If more current is required, reduce the 10kΩ resistors, possibly to 2.2kΩ or less.

High frequencies above 48kHz are rolled off by the 150pF capacitors across the 22kΩ feedback resistors. The 470pF capacitor shunting the balanced input lines, in conjunction with the microphone impedance, also roll off the high frequencies.

Ferrite beads in the 1kΩ input resistors help to reduce RF pickup, while the use of 1% resistors in the balanced microphone circuits ensures good rejection of common mode signals such as mains hum.

The unbalanced outputs are each fed to level potentiometers VR1 & VR2 via a 150Ω stopper resistor and 10µF AC coupling capacitor. The signals are then applied to op amps IC3a and IC3b, both of which have a gain of 11. This means that maximum gain for microphone signals before the mixer is 242.

Guitar input

The guitar input stage comprises IC2, a TL071 Fet input op amp connected as a non-inverting amplifier with a gain of 2 for mid-band frequencies.

The guitar signal is coupled via two 47µF capacitors in series. These are equivalent to a non-polarised capacitor and are included to cater for inputs with a positive or negative bias voltage, that goes beyond the voltage bias set by the Vref (at half supply).

We have specified the high load resistance of 1MΩ to ensure optimum high frequency response with the relatively high inductance of typical guitar pickups. With such a high load resistance, you might wonder why we have used such a large input coupling capacitance. After all, to maintain a flat response to below 20Hz, all you need is an 8.2nF input capacitor. The reason is to minimise noise, which occurs when op amp IC2 sees as low a source impedance as possible.

Output from IC2 is coupled to the "guitar" level control, VR3, via a 150Ω resistor and 10µF capacitor. The

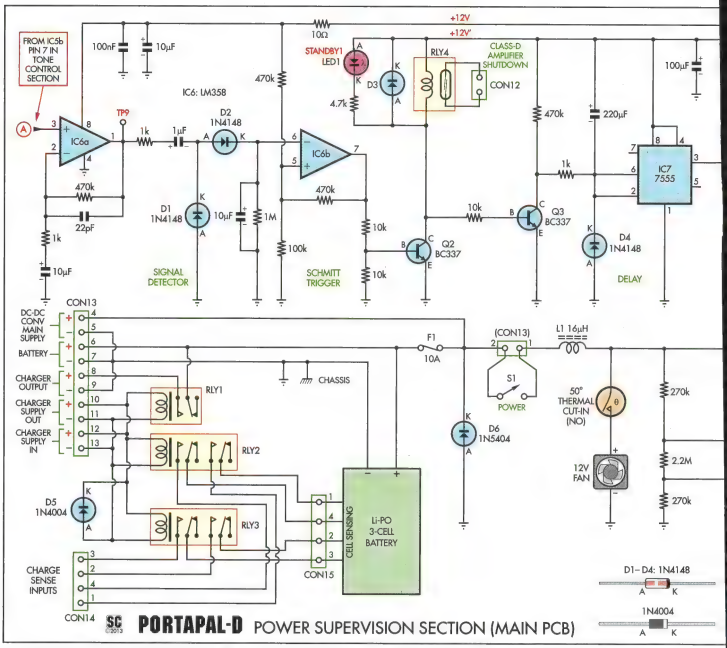


Fig.5: here's where the PortaPAL-D excels over earlier mixers – it uses a Li-Po battery and a commercial charger to give much more "bang for buck" when it comes to portable use. For a full explanation, see the accompanying text.

signal is then fed to op amp IC4a, which is identical to IC3a & IC3b.

Line signal

Stereo line inputs (eg, from a CD player or MP3 player) are mixed to a mono signal with 2.2kΩ resistors and fed to potentiometer VR4 via a 2.2µF coupling capacitor.

Signals from all four input sources are mixed via 15kΩ resistors for the mic and guitar signals and a 10kΩ resistor for the line signal in inverting amplifier IC5a. This has a gain of minus two for the first mic and guitar signals, with slightly higher gain for the line input signals (due to the 10kΩ resistor to compensate for a slight gain loss in the resistive mixing of the stereo line inputs).

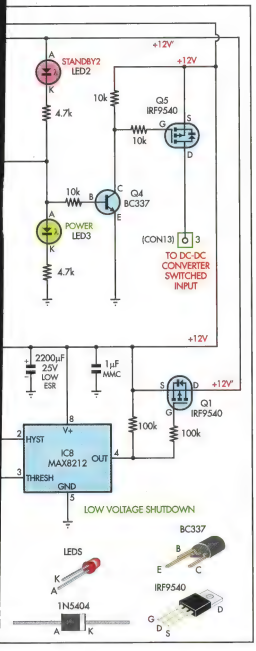
IC5a drives the tone control stage comprising IC5b, VR5 and VR6 and associated resistors and capacitors.

IC5b's output signal is fed to three separate places; the line output via RCA and 6.35mm jack sockets, the signal detection stages involving IC6a and the input to the CLASSiC-D power amplifier.

All of the op amps in the circuit used as signal amplifiers are biased via the Vref line, which is at half supply (about +6V). This is derived from the +12V line by a voltage divider consisting of two 10kΩ resistors with the centre point bypassed by a 100µF capacitor. The bypassed supply is then buffered by op amp IC4b to provide the Vref line. All these biased op amp outputs will sit at about half the battery voltage, with the audio signal rising and falling about this DC voltage

Shutdown

As noted above, we have incorporated signal detection into the circuit to shut down the power amplifier in order to reduce current consumption when no signal is present. Op amp IC6a is a non-inverting amplifier with a gain of 471, set by the 470kΩ and



1kΩ feedback resistors. The 22pF capacitor rolls the gain off above 15kHz, while the 10µF capacitor in series with the 1kΩ resistor rolls off signals below 15Hz.

The amplified signal from IC6a is then fed to a diode pump circuit consisting of diodes D1 & D2 and the 1µF & 10µF capacitors connected to them. Peak level of the signal from IC6a will be stored in the 10µF capacitor which is continuously being (slowly) discharged via the 1MΩ resistor across it.

IC6b, connected as a Schmitt trigger inverter, monitors this voltage. A 470kΩ resistor between pin 5 and pin 7 applies positive feedback to give hysteresis. This makes the comparator output switch cleanly between high and low, and to prevent oscillation at the switching threshold. The inverting input of IC6b is set at +2.1V (ignoring the effect of the 470kΩ feedback resistor) using the 470kΩ and 100kΩ resistors across the 12V supply.

When power is first applied to the circuit, the 10µF capacitor between the 12V supply and the inverting input to IC6b is initially discharged and therefore pulls pin 6 low, causing the output (pin 7) to be high. This turns on transistor Q2, so relay 4's contacts close and the CLASSiC-D amplifier is shut down.

At the same time, transistor Q3 is turned off so IC7's inputs (pins 2 and 6) are high due to the 220µF capacitor connecting to the 12V supply being initially discharged. The output (pin 3) is low so Standby 2 LED (LED2) is lit. The low output holds both Q4 off and Mosfet Q5 off. This removes power from the DC-DC converter switch and as a result the CLASSiC-D amplifier is off.

When audio signal is detected by IC6b, the input (pin 6) will go above the 2.1V at pin 5 so the output (pin 7) goes low, switching off Q2 and the relay. Diode D3 quenches the back-EMF of the collapsing relay coil field .

There is still a low current flow through the relay coil and Q3 – not enough to pull the relay in but enough to turn Q3 on. This provides a path to ground (via the 1kΩ resistor) which charges the 220µF capacitor.

The now-low input to the 7555 cause its output (pin 3) to go high, switching on power LED (LED3) and transistor Q4 and switching off the Standby 2 LED. Mosfet Q5 also switches on and the DC-DC Converter is powered, in turn powering the CLASSiC-D amplifier.

Low battery

Regardless of the battery type, it is important that it not be over-discharged and permanently damaged. While the Lithium-Polymers used in the PortaPAL-D are better than SLAs in this regard, care still needs to be taken.

Low battery voltage is detected using IC8, a micropower voltage monitor that compares the voltage at pin 3 to an internal 1.15V reference. With a 12V supply, the voltage divider across IC8s input will ensure that pin 3 is always above 1.15V. However, as the battery discharges, this voltage will drop. Below 10.5V, IC8s output (pin 4) will go high, turning off Mosfet Q1. This removes power from the rest of the circuit thus preventing the battery being discharged any further.

Pin 2 provides hysteresis, stopping the circuit oscillating back and forth around the 1.15V threshold. While ever the voltage at pin 3 stays above 1.15V, pin 2 is effectively connected to the supply rail, thus shorting out the 270kΩ resistor to 12V.

However, if the pin 3 voltage drops below 1.15V pin 2 is effectively open circuit. So that extra 270kΩ resistance is added to the voltage divider, which drops the voltage at pin 3 even lower (just over 1V with a 10.5V supply). Therefore the battery needs to be charged to more than 11.6V before the output (pin 4) goes low, allowing the Mosfet to power the circuit again.

Power

Power from the battery passes through the 10A fuse, F1 and power switch S1. Inductor L1 and the 2200µF capacitor filter the supply, helping prevent DC-DC converter switching noise from entering the supply for the audio op amps. Additional filtering is provided with the 10Ω resistor and the supply decoupling capacitors on the 12V rail.

Note that the high current supply required by the DC-DC Converter is tapped off before the switch. Only the low power switching current to control the DC-DC Converter is at the output to Q5.

Reverse polarity protection is via diode D6: this will blow the fuse if the supply polarity is inadvertently connected back to front.

Charging

Three relays are used to switch in the charger connections. The supply to the charger is tapped at pins 10-13 of CON13 so that when power is available, relays (Relay1, Relay2 and Relay3) will be switched on. The charger output is switched to the battery positive via relay 1 contacts while the cell balancing outputs from the battery are connected to the charger via relay 2 and relay 3 contacts.

When there is no power applied to the charger input, the relay contacts open and completely disconnect the charger from the battery.

PortaPAL-D – Parts List

Main PCB (Mixer and power supervision)

1 PCB coded 01111131, 212 x 100mm
1 10-way IDC PCB mount socket (CON10)
2 10-way IDC line plugs
1 100mm length of 10-way IDC cable
1 6-way SIL socket (CON11)
1 2-pin header, 2.54mm spacing (LK1)
1 2-pin polarised header, 2.54mm spacing (CON12)
2 2-way pin header sockets
1 jumper shunt
6 DIL8 IC sockets *(optional)*
2 M205 PCB fuse clips
1 M205 10A fast blow fuse (F1)
1 iron powdered toroid 28 x 14 x 11mm [Jaycar LO1244] L1
5 2-way PCB mount screw connectors (5.08mm pin spacing) (CON13)
1 3-way PCB mount screw connectors (5.08mm pin spacing) (CON13)
1 vertical PCB mount RCA socket (CON9)
2 RCA line plugs
1 12V 10 or 16A SPDT relay [Altronics S4197, S4170A, Jaycar SY-4050] (RELAY1)
2 12V 1A DPDT relays] Altronics S4150, Jaycar SY-4059] (RELAY2,RELAY3)
1 12V SPST DIL reed relay [Altronics S4101A, Jaycar SY-4032] (RELAY4)
4 16mm single PCB mount 10kΩ log potentiometers and nuts (VR1-VR4)
2 16mm single PCB mount 100kΩ linear potentiometers and nuts (VR5,VR6)
6 knobs to suit above potentiometers (4 blue, 2 grey)
3 M3 tapped spacers 15mm long
1 solder lug
4 M3 x 10mm machine screws
2 M3 x 15mm machine screws
6 pot nuts *(providing for an extra nut under potentiometer)*
1 3S 250mm 2xJST-XH parallel balance lead [http://hobbyking.com.au/hobbyking/store/__32036__JST_XH_Parallel_Balance_Lead_3S_250mm_2xJST_XH_.html]
1 1.5m length of 1mm diam. enamelled copper wire for L1
1 150mm length of 7.5A rated green hookup wire
1 150mm length of single core screened cable
1 270mm twin figure-8 light gauge wire
1 190mm length of 0.7mm diam. tinned copper wire
1 100mm cable tie
2 PC stakes

Semiconductors

2 LM833 dual low noise op amps (IC3,IC4)
1 TL072 dual op amp (IC5)
1 LM358 dual op amp (IC6)
1 7555 CMOS 555 timer (IC7)
1 MAX8212 voltage monitor (IC8)
2 IRF9540 P-channel Mosfets (Q1,Q5)
3 BC337 NPN transistors (Q2-Q4)
4 1N4148 diodes (D1-D4)
1 1N4004 1A diode (D5)
1 1N5404 3A diode (D6)
3 3mm high brightness LEDs (LED1&2 [red]; LED3 [green])

Capacitors

Electrolytic (PC type)

1 2200µF 25V low ESR
1 1000µF 16V 1 220µF 16V 3 100µF 16V 12 10µF 16V
1 10µF NP 50V 1 2.2µF NP 50V 4 1µF 16V 1 1µF 50V NP

MKT polyester

1 330nF 4 100nF 1 15nF 1 10nF 1 1.5nF

Ceramic

1 1µF monolithic multilayer (MMC)
3 330pF 1 100pF 1 47pF 1 22pF

Resistors (0.25W, 1%)

1 2.2MΩ 1 1MΩ 4 470kΩ 2 270kΩ 6 100kΩ
1 47kΩ 2 30kΩ 2 18kΩ 3 15kΩ 15 10kΩ
3 4.7kΩ 7 1kΩ 2 150Ω 2 10Ω

Guitar input, line input and output PCB

1 PCB coded 01111133, 109 x 35mm
2 PCB mount 6.35mm switched jack sockets (CON4,CON7)
2 stereo RCA vertical stacked PCB mount (CON5,CON6)
1 10-way IDC PCB mount socket (CON8)
1 DIL8 IC socket (optional)

Semiconductors

1 TL071 single op amp (IC2)

Capacitors

Electrolytic (PC type)

2 47µF 16V 2 10µF 16V 1 2.2µF 16V PC
1 100nF MKT polyester 1 680pF ceramic 1 10pF ceramic

Resistors (0.25W, 1%)

1 1MΩ 1 10kΩ 2 4.7kΩ 2 2.2kΩ 1 1kΩ 1 150Ω

Microphone input PCB

1 PCB coded 01111132, 64 x 73mm
2 PCB mount XLR female connectors [Altronics P 0883] (CON1,CON2)
1 right angle 6-way pin header with backing plate removed (CON3)
1 chassis mount 6.4mm spade terminal
1 female spade 6.4mm quick connector
4 ferrite beads 4mm ID x 5mm long [Jaycar LF-1250 or equivalent]
1 DIL8 IC socket *(optional)*
4 4g x 6mm self tapping screws or M3 x 6mm screws
1 M3 x 10mm machine screw
1 M3 nut
2 3mm star washers

Semiconductors

1 LM833 low noise dual op amp (IC1)

Capacitors

4 47µF 16V PC electrolytic 2 10µF 16V PC electrolytic
1 100nF MKT polyester 2 470pF ceramic
4 150pF ceramic

Resistors (0.25W, 1%)

4 22kΩ 7 10kΩ 4 1kΩ 2 150Ω

Extras

1 CLASSIC-D amplifier set for a ±35V output
(see Silicon Chip November & December 2012)
1 speaker protector for the CLASSIC-D set for a 35V supply
(see Silicon Chip, November/December 2012)
1 50°C NO thermostat (Jaycar ST-3831)
1 10µF 16V PC electrolytic capacitor *(used in speaker protector)*
1 DC-DC Converter for the CLASSIC-D *(see Silicon Chip, May '13)*
1 10kΩ 0.25W 1% resistor *(used in DC-DC converter)*
1 Li-Po 11.1V battery (ZIPPY Flightmax 8000mAh 3S1P 30C)
(http://hobbyking.com.au/hobbyking/store/__19530__ZIPPY_Flightmax_8000mAh_3S1P_30C_AUS_Warehouse_.html
1 HobbyKing E4 Li-Po balance charger
(http://hobbyking.com.au/hobbyking/store/__14633__HobbyKing_E4_Balance_Charger.html)
1 Polymax 5.5mm Gold Connector plug and socket set [Jaycar KG55001 set of 10 but only one plug and one socket required]
(http://hobbyking.com.au/hobbyking/store/uh_viewitem.asp?idproduct=18659)
1 strap handle [Jaycar HS-8022, Altronics C 3660]
1 1.8m x 3m speaker box carpet [Jaycar CF-2755]
8 corner protectors [Jaycar HM-3843 (or HM-3829 – pack 8), Altronics C 3620 or C 3623]
1 speaker box "top hat" mount [Jaycar HS-8035, Altronics C 3602]
2 200mm speaker grilles [Jaycar AX-3594, Altronics C 3708]
2 8Ω 200mm coaxial speakers [Altronics C 2005]
1 40mm 12V fan [Jaycar YX-2502, Altronics F 0010]
1 SPST mini rocker switch (S1)
2 9mm M3 tapped standoffs *(for fan)*
2 M3 x 10mm countersunk screws *(for fan mounting standoffs to chassis)*
2 M3 x 15mm machine screws (*for fan mounting to standoffs)*
1 solder lug
1 "P" cord clamp with M3 x 10mm screw, nut and washer
2 6.4mm crimp female spade connectors
1 200mm length of 10mm diameter heatshrink tubing *(for covering charger and battery bracket)*
1 red right angle banana plug [Jaycar PP-0394]
1 black right angle banana plug [Jaycar PP-0395]
1 2.5mm DC panel connector
1 2.5mm DC line plug
2 aluminium sheets 295 x 295mmm, 1mm gauge [Jaycar HM-9500]
1 350mm length of 12mm x 3mm aluminium
6 M3.5 tapped right angle (RA) bracket standoffs [Jaycar HP-0872]
16 M3 x 10mm machine screws *(for mounting PCBs to chassis RA brackets to chassis – see note in construction article)*
7 M3 x 15mm machine screws *(3mm aluminium brackets to RA brackets, through 12mm standoffs on brackets 3mm aluminium to standoffs)*
1 M3 x 20mm machine screw
10 M3 x 6mm countersunk screws *(DC-DC Converter mounting, battery and charger brackets, RA brackets to chassis)*
12 M3 nuts *(RA brackets)*
2 small cabinet handles (45mm long x 15mm high x 6mm wide or similar) *(optional)*
1 2-way 15A terminal strip *(optional for extension speaker)*
1 1m length of 7.5A figure-8 wire for speaker connections
3 1m lengths of 7.5A hookup wire (1 each red, black, green)
2 25mm length of 6mm heatshrink tubing (1 each red & black)
2 25mm length of 10mm heatshrink tubing (1 each red & black)
2 100mm cable ties

Box Hardware

8 8g 12mm panhead wood screws *(for speaker mounting)*
24 6g 16mm countersunk wood screws (bronze) *(for attaching corner protectors)*
5 4g x 16mm panhead screws *(for mounting the chassis to the cabinet)*
1 500ml tin of contact adhesive
2 strips of putty adhesive *(eg, Blu-Tack)*
2 cushion bags of polyester wadding *(eg, Innerbond)*
1 3m length 18mm x 18mm DAR (dressed all round) pine
1 6m length 12mm x 12mm DAR pine
2 900mm x 600mm x 16mm sheets of MDF (or single 1800 x 600mm x 16mm sheet)

Resistor Colour Codes

Total No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑ 1	2.2MΩ	red red green brown	red red black yellow brown
❑ 2	1MΩ	brown black green brown	brown black black yellow brown
❑ 4	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑ 2	270kΩ	red violet yellow brown	red violet black orange brown
❑ 6	100kΩ	brown black yellow brown	brown black black orange brown
❑ 1	47kΩ	yellow violet orange brown	yellow violet black red brown
❑ 2	30kΩ	orange black orange brown	orange black black red brown
❑ 1	27kΩ	red violet orange brown	red violet black red brown
❑ 4	22kΩ	red red orange brown	red red black red brown
❑ 2	18kΩ	brown grey orange brown	brown grey black red brown
❑ 3	15kΩ	brown green orange brown	brown green black red brown
❑ 22	10kΩ	brown black orange brown	brown black black red brown
❑ 4	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑ 2	2.2kΩ	red red red brown	red red black brown brown
❑ 12	1kΩ	brown black red brown	brown black black brown brown
❑ 3	150Ω	brown green brown brown	brown green black black brown
❑ 2	10Ω	brown black black brown	brown black black gold brown

Capacitor Codes

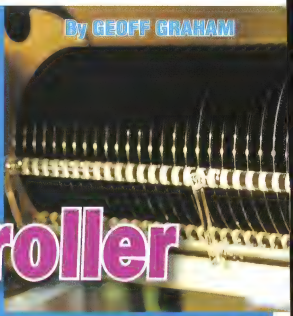
Value	µF Value	IEC Code	EIA Code
330nF	0.33µF	330n	334
100nF	0.1µF	100n	104
15nF	0.015µF	15n	153
10nF	0.01µF	10n	103
1.5nF	0.0015µF	1.5n	152
680pF	NA	680p	680
470pF	NA	470p	470
330pF	NA	330p	330
150pF	NA	150p	150
100pF	NA	100p	100
47pF	NA	47p	47
22pF	NA	22p	22
10pF	NA	10p	10

NEXT MONTH:

We'll present Part 2 with all the construction details, including making & wiring the electronics. SC

The new PIC32MZ microcontroller

By GEOFF GRAHAM



We first introduced Microchip's then new PIC32 microcontroller to Silicon Chip readers back in March 2011. At the time, we marvelled at its capabilities and went on to use it in our popular Maximite series of computers. Now Microchip has an updated version which was released just a few weeks ago. It's called the PIC32MZ.

This photo shows one of the TSMC semiconductor fabrication plants located in Hsin Chu, Taiwan where the PIC32MZ is manufactured. Photo courtesy Taiwan Semiconductor Manufacturing Co Ltd.

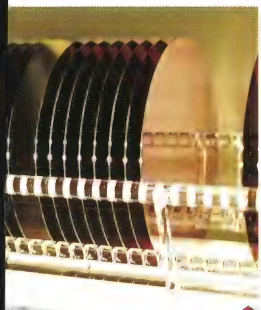
The PIC32MZ has over three times the speed and four times the memory capacity of its predecessor and includes a new central processor and better peripherals. Photo courtesy Microchip.

IN REALITY, the PIC32MZ is more than just a simple update. With over three times the speed and four times the memory capacity of its predecessor, it's better described as a leap forward. This new chip also has a new central processor, better peripherals and new features such as the ability to remap I/O pins to make the PCB layout more efficient.

Speed & memory

The headline features of this new chip are its vastly improved speed and memory capacity. The PIC32MZ will run at up to 200MHz and has up to 2048KB of flash memory and 512KB of RAM (both four times that of the PIC32MX series).

There are chips on the market with a higher speed and with support for more memory – such as the ARM-based processors typically found in mobile phones. However, these generally require additional RAM and flash memory chips, increasing PCB



This is an example of the silicon wafer on which the PIC32MZ is fabricated. It is the percentage of working chips on the wafer (the yield) that is important to the profitability of the manufacturer. Photo courtesy Taiwan Semiconductor Manufacturing Co Ltd.

complexity, or else have significantly less RAM and flash. By contrast, the PIC32MZ integrates all of these features and more onto a single chip.

Because the PIC32MZ is a complete microcontroller, it's simple for designers to use. It just needs a supply of 2-3.6V (a couple of 1.5V cells will do) and some decoupling capacitors – no other support circuitry is required. You then have a very fast chip that has plenty of capacity for almost any job you could think of – even if it requires multiple communications stacks, full colour graphics, audio processing and more.

The main programming language for the PIC32MZ is C and as long as you are happy writing in this language, you will find that developing software for this chip is relatively painless. This is due to the chip's easy-to-use 32-bit architecture and the free support software provided by Microchip which includes the development environment, compilers and application libraries.

New CPU

The PIC32MZ uses the new 32-bit microAptiv MPU processor core from MIPS (Fig.2). This is an advanced processor consisting of millions of transistors and can operate in either 16-bit instruction mode for small code size or 32-bit mode for speed and computational power.

The processor can run at up to 200MHz, which means that it will run your code at roughly three times the speed of the older series. This core is also backwards-compatible with the M4K core used in the earlier PIC32 microcontrollers, so existing firmware can be easily be ported.

To improve performance, large RAM caches are used for both the instruction and data streams. The instruction cache is especially important because flash memory is quite slow and without a cache the processor would run at just one-half of its capability.

Performance is also helped by a bus matrix which connects the input/output interfaces directly to the memory and bypasses the central processor. This frees up the processor since it is not required to copy each data byte to the interface.

Perhaps the most exciting feature of the microAptiv MPU core is that it contains a Memory Management Unit (MMU) which is required by advanced operating systems like Linux. So in all probability, we will see Linux running on the PIC32MZ in the future.

Another important feature of the PIC32MZ is that it's economical in its power consumption and draws just 200µA per MHz of clock speed. At its maximum clock speed of 200MHz, the PIC32MZ will draw about 40mA which is half the current drawn by previous PIC32 chips when running at 80MHz.

Die shrink

Faster speed, increased complexity and less power all point to what the semiconductor industry calls a "die shrink" – a reduction in the dimensions of the transistors used in the chip. By shrinking the transistors, more can be crammed onto the same-sized chip and because they are smaller, each transistor will switch faster while drawing less current.

For the PIC32MZ, the die shrink involved moving from a 180nm process to a 90nm process. This isn't at the leading edge of technology (which can be as small as 14nm) but it's excellent for a low-cost chip.

The downside of a die shrink is that it's harder to make the chip and the production process has to be carefully managed to ensure that enough working chips are produced on each silicon wafer. This is the "yield" and a manufacturer can live or die on this statistic.

Peripherals

While a high-speed processor is important, it's the peripherals that make it practical to use the device in a circuit. These peripherals are the subsystems and include timers, I/O ports, communications interfaces and so on – all the things that make the chip useful as an embedded microcontroller.

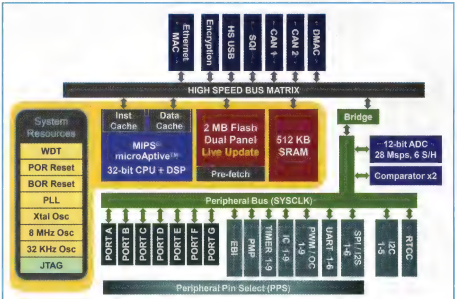


Fig.1: the internals of the PIC32MZ are complicated and more like a full-sized computer than a microcontroller. Two important features are the "High Speed Bus Matrix" and the "Peripheral Bus" which facilitate interconnections to peripherals without the involvement of the CPU. Diagram courtesy Microchip.

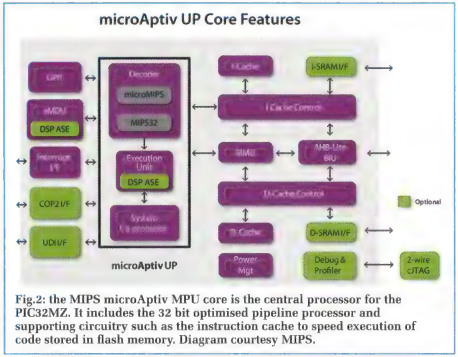


Fig.2: the MIPS microAptiv MPU core is the central processor for the PIC32MZ. It includes the 32 bit optimised pipeline processor and supporting circuitry such as the instruction cache to speed execution of code stored in flash memory. Diagram courtesy MIPS.

The PIC32MZ can communicate with external devices in many different ways. One is via a 10/100 Ethernet Media Access Controller (MAC) which is integrated on the chip. With the addition of a driver chip (called a "PHY"), you can then connect the PIC32MZ to an ethernet network.

Another important interface is the USB 2.0 high-speed interface which can work both as a host and as a device. This means that you can design an appliance which allows the user to:

- plug in a USB memory stick or USB printer; or
- connect the PIC32MZ to a computer as a device for uploading and downloading data.

Other communications interfaces integrated on the chip include CAN (which is used in OBD2 for the automobile industry), serial UARTs, SPI, I²C and parallel ports. One very useful feature is that you can select what I/O pins most of these interfaces appear on. This simplifies board layout and it means that you do not have to resolve a conflict when multiple interfaces want to use the same set of I/O pins.

Audio & graphics

Furthering this high level of integration, the PIC32MZ includes peripherals which make it easy to generate high-quality graphics and audio outputs. The External Bus Interface (EBI) and Parallel Master Port (PMP) interfaces facilitate communications with graphical LCDs and other parallel devices.

The SPI/I²S module provides a synchronous serial interface that is useful for communicating with digital audio devices and external serial devices. I²S is the standard for communicating with digital audio converters (DACs) and with the right DAC, the PIC32MZ can generate very high quality audio.

There are many more features of this chip that are outstanding (eg, a 12 bit analog converter, a DSP instruction set and a real time clock) but rather than describe them all, it's sufficient to say that the PIC2MZ is packed with almost everything that you might want in a microcontroller.

Applications

Most PIC32 chips have ended up in general consumer or industrial applications. Microchip would like to build on this market with the PIC32MZ and a focus on connectivity, graphics and audio.

The attention to connectivity is particularly important as electronic devices are becoming increasingly interconnected, especially via the internet. In our review of the Altronics A2696 Internet Radio (elsewhere in this issue), we saw how it uses the internet to retrieve details of the radio stations that are available. In the future, more appliances will follow this trend.

It could be a printer that connects to the internet to order fresh ink supplies when they are running low, a TV set that downloads programming information or a home medical appliance that emails medical updates to the patient's doctor.

Another example where connectivity could be exploited is a photocopier where the rental cost is based on the number of copies made. The copier could automatically "phone home" with this data. Even better, the photocopier could include its own web server so that the customer could use a browser to access it and monitor the number of copies per day and the associated cost.

Internet of Things

All this can be easily handled by the PIC32MZ and is part of a new concept called the "Internet of Things". This is an evolving term and refers to

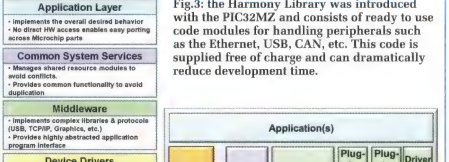


Fig.3: the Harmony Library was introduced with the PIC32MZ and consists of ready to use code modules for handling peripherals such as the Ethernet, USB, CAN, etc. This code is supplied free of charge and can dramatically reduce development time.

Because the PIC32MZ uses very fine dimensions for each transistor, any minute imperfection or dust particle could ruin the chip during manufacture. This means that cleanliness is important inside the fabrication plant, Photo courtesy Taiwan Semiconductor Manufacturing Co Ltd.

intelligent devices that can exchange information between themselves and master servers. Examples include alarm systems, home automation, vending machines, fleet management and other applications that require remote monitoring.

The idea is that people do not need to handle mundane tasks such as diagnosing a fault in an item of equipment. Instead, the equipment itself could signal a fault to its service centre and a technician would be automatically dispatched with the appropriate spare part.

This is not as outlandish as it sounds. Already in large data centres, equipment such as disk arrays are remotely monitored and a technician is dispatched if a disk drive has failed. Because the array has built in redundancy, the operators of the data centre are often not aware of the fault until the technician arrives on their doorstep with the spare part.

Everyday tasks

If you are an experimenter, you are probably wondering "would I have a use for such a powerful chip?". The answer is "yes", because you do not have to use everything it offers. In fact, it's quite cost efficient for the experimenter who wants to use it for all sorts of everyday tasks.

If you do not want to use the audio interface or the DSP instructions or some other feature, it doesn't matter. You can simply leave them turned off and they will not consume any power. At a price of $US9.64 to $US14.35 for a single chip direct from Microchip, the cost of the unused features can be regarded as trivial.

The chip is forgiving when it comes to a power supply (2-3.6V) and the 32-bit environment makes programming relatively simple. Throw in the free software tools and C compiler provided by Microchip and you have an inexpensive and easy solution for your next microcontroller project.

About the only issue with the PIC32MZ is that it comes in a TQFP package with a pin spacing of 0.5mm. These days, that shouldn't be a barrier because the chip can be easily soldered to an adaptor board which will bring the chip's pins out to a connector with an easy 0.1-inch pitch. If you Google "tqfp adapter". you will find many sources.

Harmony Software Library

One area where programming could be difficult for the earlier PIC32 is when interfacing to items such as USB, ethernet, SD memory cards and other complicated devices. In the past, Microchip provided individual software modules to cover these requirements but with the introduction of the PIC32MZ, they have launched the "Harmony Software Library" to provide this support.

This is an integrated library of code modules that wraps support for most of the PIC32MZ's features into easy-to-use functions that can be called from your C program. A good case in point is the TCP/IP library which includes a web server, FTP, Telnet, email and more.

Using Harmony, these functions

Creating A New PIC Microcontroller

The PIC32MZ is an international affair. Designed in Arizona, the chips are fabricated in Taiwan and packaged in Thailand. The development process started in March 2011 and over the following 2½ years, a core group of about 30 engineers worked on the design. They were supported by many others in marketing, test and production.

The first stage of development involved the creation of a 90nm library of components like transistors, gates, I/O pads, etc. At the same time, the specifications for the main chip and each module inside the chip were developed. These came from Microchip's assessment of what features customers would demand of the chip and the target price once it was in production.

Design engineers then worked for more than a year to turn the specifications into a register-transfer level (RTL) design. RTL is a high-level description of the flow of signals between registers and is used in the semiconductor industry to specify the logic of the chip in detail.

The largest component of the design was the processor core which was supplied by MIPS as an RTL package. The design of a 32-bit processing core such as this is a complex process which is why most semiconductor manufacturers licence a design from specialist companies like MIPS and ARM, rather than try to design and support their own.

The RTL description was then converted to a gate-level description of the circuit by a logic synthesis software package. The results were then used by other software tools to place the components and route the interconnects to create the physical layout of the chip. At this stage, engineers could run software simulations to verify that the logic worked as expected.

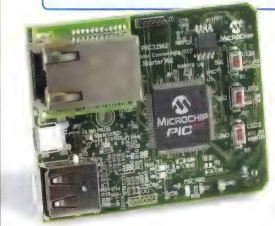
With the chip layout prepared, the first batch of chips became available for testing in March 2013. Subsequently, a number of silicon revisions were produced as bugs and other issues were found and corrected. It takes some time to test every possible configuration of a device containing millions of transistors and the task, involving numerous test engineers and willing customers, took almost a year.

In addition, documentation needed to be written, training courses prepared, support engineers trained and the software drivers for the Harmony library had to be written and tested. As an indication of the work involved, the data sheet and reference manual for the new PIC32MZ micro runs to over 2000 pages.

The actual production of the chip is subcontracted by Microchip to TSMC, located in Hsin Chu, Taiwan. TSMC is a "silicon foundry" specialising in the production of semiconductor chips for other companies. These plants can cost billions of dollars to set up which is why companies such as Microchip prefer to outsource the manufacturing process rather than tie up so much capital in a specialist plant.

In the final step of production, the raw chips are sent to Microchip's own facility near Bangkok, Thailand where they are tested, mounted and packaged to make them ready for shipping.

It is a truly enormous effort by a world-wide team of engineers and specialists to develop the chip and deliver it into your hands, along with the supporting documentation and software.



The PIC32MZ "Embedded Connectivity Starter Kit" from Microchip.

can be conveniently added to your firmware.

Other examples include USB support (both as a host and a device), FAT16 and FAT32 file systems for SD cards and USB memory sticks, graphics libraries and protocols such as CAN, serial, SPI and I^2C. These modules have all been tested and it only takes a little work to integrate them into your program.

The library also contains a number of Real Time Operating Systems (RTOS) and all of the modules in Harmony are designed to work with an RTOS. This is significant because with the complex tasks that this chip will be expected to undertake, the programmer needs an operating system to partition the software into manageable sections while still efficiently responding to real world events.

According to a recent survey (2013 Embedded Market Study by UBM Tech), almost two thirds of the cost of an embedded processor project was in writing and debugging the firmware. This is where a software library like Harmony becomes important – if you can simply drop in a complex module rather than write it yourself, it will have a large impact on the project's overall development cost.

The PIC32MX250

While we're talking about the PIC32 line, we should also briefly mention the PIC32MX250 which was launched late last year. This is a slower version of the PIC32 (it runs at 40MHz) and is intended for less demanding applications. It contains the full MIPS Mk4 32-bit processing core, 128kB of flash memory and 32kB of RAM, along with most other features of the larger PIC32MX line.

It comes in a 28-pin dual-in-line package which is easy to solder and can be plugged into an IC socket. It is also very affordable at just US$3.80 in single quantities (direct from Microchip).

The PIC32MX250 is perfect for the hobbyist because it is simple to use yet has most of the power of the 32-bit line. We used this chip in the GPS Tracker published last month and it handled the task with ease and with plenty of capacity to spare.

With their sharp prices and performance advantages, Microchip's 32-bit processors are taking over most of the jobs previously reserved for 16-bit processors. In addition, low-cost variants like the PIC32MX250 make a better choice for simple tasks that were previously relegated to the aging but similarly priced 8-bit chips. SC

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See pages 4-5 for more tools!

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GPS Data Logger/Tracker Kit

Ref: Silicon Chip Mag November 2013

Precisely records where your car or boat has travelled over time, which you can playback on software such as Google Earth to map your journey. Kit supplied with silk-screened PCB, enclosure with label, pre-programmed PIC, GPS module, and electronic components. The SMD components are already pre-soldered to the PCB to save you the hassle.

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- Records point-of-interest at the touch of a button
- 12VDC powered

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- Requires 3 x AA batteries
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- Size: 710mm long

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- Comprehensive instructions included
- No soldering required

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See pages 2-3 for more ARDUINO!

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- Suitable for ages 8+

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A fantastic electronic bug habitat set.

- Suitable for ages 5+
- Includes two 45mm long bugs

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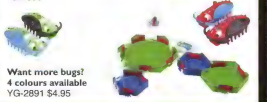

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ARDUINO

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LeoStick

A tiny Arduino-compatible board that's so small you can plug it straight into your USB port without requiring a cable!

- Analogue & digital I/O
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Also available **LeoStick Prototyping Shield** XC-4268 $7.95

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EtherTen

Includes onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, and even Power-over-Ethernet support.

- ATmega328P MCU running at 16MHz
- 10/100base-T Ethernet built-in

XC-4216

$69.95

Eleven

The "Eleven" is just like an Arduino Uno - but better! It's a microcontroller board based on the ATmega328 with 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

XC-4210

$39.95

EtherMega

The ultimate network-connected Arduino-compatible board: combining an ATmega2560 MCU, onboard Ethernet, a USB-serial converter, a microSD card slot for storing gigabytes of web server content or data, power-over Ethernet support, and even an onboard switchmode voltage regulator so it can run on up to 28VDC without overheating.

- 10/100base-T Ethernet built-in
- 54 digital I/O lines
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WHAT IS ARDUINO?

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs (includes Jaycar stepper motors). Arduino projects can be stand-alone, or they can be communicated with software running on your computer. These Arduino development kits are 100% Arduino-compatible. Designed in Australia and supported with tutorials, guides, a forum and more. A very active worldwide community and resources are available with many projects, ideas and programs available to freely use. Learn more at **www.jaycar.com.au/arduino**

Arduino Books

Getting Started with Sketches

An entry level book introduces the Arduino programming language and then describes the basic configurations of Arduino modules.

- Soft cover, 162 pages
- 138 x 215mm

BM-7133

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30 Arduino Projects for the Evil Genius

This is a practical project oriented book describing lots of projects based around the Arduino microcontroller.

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- Soft cover, 191 pages
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A project oriented book written around Android-type mobile phones and the Arduino microcontroller.

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Guides you through the construction of 7 robots that roll, walk, talk, slither and even sling insults at you.

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Arduino Shields

ProtoShield Basic

Low-cost Arduino prototyping shield that enables you to make more durable or permanent projects. It fits directly to the "Eleven" (XC-4210).

- Gold-plated surface
- Top and bottom overlay
- Yellow solder mask

XC-4214

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ProtoShield Short

A dedicated short version prototyping shield for EtherTen (XC-4216) and EtherMega (XC-4256) and designed to fit neatly behind the RJ45 Ethernet jack.

- Gold-plated surface

XC-4248

$4.95

Terminal Shield

A special prototyping shield for Eleven (XC-4210) and USBDroid (XC-4222) that provides handy screw terminals on both edges for easy and secure connection.

- Gold-plated surface
- Large prototyping area

XC-4224

$16.95

433MHz Receiver Shield

Lets you intercept 433MHz OOK/ASK signals, decoding them in software on your Arduino. All the Arduino headers are broken out to solder pads, and GND and 5V rails are provided for convenience.

- Red and green user-defined LEDs
- Gold-plated surface

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RFID Lock Shield Kit

This shield enables your Arduino to control a door lock using an electric strike plate and one of a number of commonly available RFID modules.

- Supported readers include ID12, ID20, RDM630, RDM880, and HF MultiTag

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Security Sensor Shield Kit

Allows up to 4 security sensors to be connected to an Arduino with full End-Of-Line (EOL) support to detect tampering with the sensors or cable. EOL technology allows the system to detect a variety of events using a single cable pair to the sensor.

- Status LEDs on each channel

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ARDUINO

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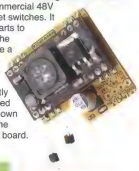
Send power to your Arduino project over the network! This regulator module fits onto the Freetronics EtherTen or EtherMega to make them compatible with commercial 48V Power-over-Ethernet switches. It includes built-in smarts to communicate with the switch and negotiate a power rating for the device, then uses a switch-mode regulator to efficiently drop the 48V supplied via the LAN cable down to 7.5V for use by the Arduino compatible board.

XC-4252



$29.95

In store ONLY. Limited stock. Not available online.

ICSP Programmer

Program new applications into a wide range of microcontrollers using this ICSP programmer with a USB interface.

- Compatible with Arduino boards (ZZ-8726) ATmega328P MCU
- Fully supported by the Arduino IDE

XC-4237

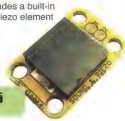
$24.95

In store ONLY. Limited stock. Not available online.

Arduino Modules

Sound & Buzzer Module

This versatile piezo-element module can be used for both input or output! Includes a built-in 1M resistor to allow the piezo element to detect shocks.



- Sound pressure level at 10cm: 75dB (min)
- Size: 23(W) x 16(H) x 5(D)mm

XC-4232

$9.95

Full Colour RGB LED Module

An LED with a brain! This smart module can be daisy-chained, so you can connect a number of these together in a string and drive each of the module colours individually from your microcontroller.

- Size: 18(W) x 18(H) x 5(D)mm

XC-4234

$9.95

Temperature Sensor Module

Sprinkle these around your house to collect temperature data using your Arduino. Two sets of header connections to allow easy daisy-chaining.

- -55 to +125˚C temperature range
- +/-0.5˚C accuracy
- Selectable 9 or 12 bit precision
- Unique device ID coded into every sensor
- Size: 23(W) x 16(H) x 6(D)mm

XC-4230

$16.95

ATmega328P MCU with Arduino Uno Bootloader

An Atmel AVR ATmega328P microcontroller to build customised Arduino compatible projects. Includes 16Mhz Crystal Oscillator.

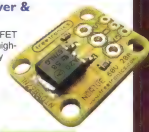
- Pre-installed Arduino Uno bootloader

ZZ-8726

$9.95

N-MOSFET Driver & Output Module

This high-power N-MOSFET module lets you switch high-current loads using a tiny microcontroller.



- Maximum 60V / 20A switched load
- Drive directly from an Arduino digital output
- Size: 23(W) x 18(H) x 5(D)mm

XC-4244

$6.95

Microphone Sound Input Module

Give your project ears with this sound response and sound pressure level sensing module. Designed to connect straight to an Arduino compatible, microcontroller analog to digital converter or many other circuits.

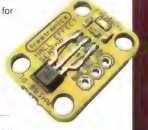
- Size: 23(W) x 16(H) x 8(D)mm

XC-4236

$9.95

Hall Effect Magnetic & Proximity Sensor Module

Sense magnetic presence, rotating wheels and magnets, door and arm sensors, and anything else magnetic nearby this sensor.



- Green "triggered" LED for easy setup and use
- Size: 21(W) x 16(H) x 4(D)mm

XC-4242

$9.95

USB Lipo Charger

Charge Li-Po cells from any USB source, USB plugpack, laptop or PC.

- 3.7V output for a single Li-Po cell
- Micro-USB jack

XC-4243

$12.95

Arduino Displays

128x128 Pixel OLED Display Module

High resolution, full colour OLED display module! Perfect for graphics, gauges, graphs, even make your own video game or interactive display.

- 16,384 full colour RGB pixels in a 128 x 128 format
- Active display area 28.8 x 26.8mm, (1.5" diagonal)

XC-4270

$49.95

16 x 2 LCD Display

Handy 16-character by 2-line display ready to plug straight in to your Arduino, with a software-controllable backlight and 5 buttons for user input. The display can be panel mounted if required.

- 2 rows of 16 characters
- Software-controlled backlight

XC-4218

$29.95

Blue Dot Matrix LED Display Panel

This large, bright 512 LED matrix panel has onboard controller circuitry designed to make it easy to use straight from your board.

- 32 x 16 high brightness Blue LEDs (512 LEDs total) on a 10mm pitch
- Viewable over 12 metres away

XC-4251

Also available **Red Large Dot Matrix LED Display Panel** XC-4250 $39.95

$89.95

Note: Can for comparison only

Jaycar electronics
Better, More Technical

Meters & Testers

Multimeter with Data Hold

A handy digital multimeter with lots of features at a great price. Supplied with holster and probes.

- 2000 count
- Transistor & Diode test
- 10A DC current
- Size: 145(L) x 65(W) x 35(H)mm

QM-1523

$14.95

True RMS Autoranging DMM with Temperature

Includes non-contact voltage testing, backlit LCD, and a carrying pouch.

- 4000 count
- Powered by 1 x 9V battery (included)
- Size: 138(L) x 68(W) x 37(D)mm

QM-1551

NEW

$59.95

Multifunction Environment Meter

Combines the functions of a sound level meter, light meter, humidity meter and temperature meter.

- 4000 count
- Non contact voltage
- Size: 170(H) x 78(W) x 48(D)mm

QM-1594

$99.00

1MHz Handheld Function Generator

A signal generator with the features of a bench top generator in a portable size! Produces sine, square, and triangle waveform signals with output frequency adjustment from 1Hz to 1MHz with maximum amplitude of 8Vpp. See website for specifications.

- Backlit LCD
- Built-in rechargeable battery
- Size: 114(H) x 74(W) x 29(D)mm

QT-2304

$199.00

10MHz Rechargeable Pocket Scope

A complete portable oscilloscope! Aside from standard scope features, it has nifty tools for measurement of RMS speaker power, display hold function, and memory storage for 2 signals. Housed in a durable rubber surround. See website for full specifications.

- LCD display
- Built-in rechargeable battery
- CRO probe and USB charge cable supplied
- Size: 114(H) x 74(W) x 29(D)mm

QC-1914

$249.00

Accessories Must Haves!

HQ Banana Piggyback Test Leads

A set of factory-moulded piggy-back style banana plugs, each connected by one metre of high-quality 500VDC 12A rated cable.

- Contains 2 x black, 2 x red and 1 each of blue, yellow and green leads - 7 in all

WT-5326

$24.95

Retractable Alligator Test Lead Set

Set of 3 heavy duty red, black, and green leads on a retractable 3m reel, terminated with insulated alligator clips. Ideal for testing and troubleshooting electronic systems.

- 3m length

WT-5334

$14.95

Professional Laser Distance Meter with Smartphone App

Can be paired with a Smartphone to email measurements with a picture or upload to the cloud. The unit will measure distance, area, and volume and will store the last 20 measurements for easy comparison and referral.

- Digitech LDM app available for Android and iOS devices
- Requires 2 x AA batteries

QM-1624

NEW

$209.00

Jumper Lead kits

Ideal for connecting devices for testing.

Standard WC-6010 $6.95
Heavy Duty WC-6020 $11.95

FROM **$6.95**

Professional Multimeter Probes

Suitable for inserting and holding in 4mm banana sockets. Probe safety cover with slot for delicate work. Comfortable and ergonomic grip.

- Sold as a pair

WT-5338

$17.95

Digital Thermometer with K-Type Thermocouple

Suitable for the lab, workshop or in the field. It features an excellent measurement range from -50 to 750˚C and a hold function to lock the reading on the display. Thermocouple and battery included.

- LCD
- Pocket size

QM-1602

$39.95

Testers Under $50

Autoranging SMT DMM

Specifically designed for SMT work with interchangeable probes and tweezer probes.

- Autoranging
- Continuity test
- 6000 count
- Size: 110(H) x 36(W) x 1(D)mm

QM-1496

$39.95

Electrical Tester with Polarity Checking

The unit will indicate the nearest voltage up to 690V with polarity indication. It will also check for low impedance, continuity, do a single pole phase test and show rotary field indication. Includes 2 x AAA batteries.

- IP64 rated
- Size: 240(H) x 78(W) x 40(D)mm

QP-2286

$49.95

Automotive Multi-Function Circuit Tester

Designed to test the electrical system of 12/24V vehicles and sends voltage to components to test functionality without jumper wires. It also tests polarity, voltage, short/open status, lights and more.

- Size: 240(L) x 78(H) x 40(W)mm

QM-1494

$49.95

In store ONLY. Limited stock. Not available online.

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

Hand Tools

Jaycar Electronics — Better More Technical

Side Cutters

High quality small side cutters with 2mm thick blades and comfortable soft plastic spring loaded handles.

• Stainless steel
TH-1890

$13.95

Long Nose Pliers

Perfect for adjusting and bending components, picking up dropped nuts etc. Comfortable spring loaded handles.

• Stainless steel
TH-1893

$13.95

Crimping Tool for Non-Insulated Lugs

Solid box joint & crimping dies, comfortable handles and spring-loading make this an easy crimper to use all day.

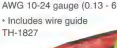
• Built-in wire cutter
TH-1834

$14.95

HD Wire Stripper / Cutter / Crimper with Wire Guide

Designed for easy wire stripping, cutting and crimping, all types of cable from AWG 10-24 gauge (0.13 - 6.0mm).

• Includes wire guide
TH-1827



$29.95

Watch Repair Tools

ALL DUE EARLY DECEMBER.

Watch Case Opener Set

NEW

This set consists of an adjustable opener that engages the little recesses on the back of a watch and the other half of the set looks like a small oyster shucking knife.
TH-1929

$14.95

Watchmakers Mallet with Interchangeable Heads

Features 6 different heads, 4 steel ones, a brass one and acrylic plastic one. Ball pein on the opposite end.

• 185mm long
TH-1927

NEW

$9.95

Micro Driver Set

This handy set will fit the bill for all those microscopic fasteners. The ergonomic handles are colour coded for easy identification and they come in a sturdy storage case. See website for contents.

• 15 piece
TD-2069

$24.95

Watch Case Holder

Sturdy adjustable frame, with 4 nylon retaining posts to enable a good safe grip on the watch case. The frame could then be held in a vice, freeing up your hands.
TH-1934

NEW

$8.95

Note: Watch not included

Watch Bracelet Link Removal Pliers

Remove and reinstall the fiddly little bracelet pins. It comes with a 1.0mm and 0.8mm pin removal insert.
TH-1923

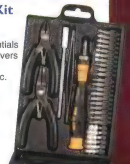
NEW

$29.95

Electronic Tool Kit

An excellent tool kit for electronic or computer repairs with all the essentials - cutters, pliers, screwdrivers (Phillips head, slotted, Posidrive), nut drivers etc. See website for full contents.

• 30 piece
TD-2107



$29.95

Wrist Strap Spring Bar Assortment

A selection of the little spring bars that get broken/bent/lost even by the most careful wearers. Consists of 340pcs in total of the most common sizes.

• Supplied in quality compartment case
TH-1928

NEW

$14.95

Watchmakers' Kit

Kit includes watch case opener/holder, retaining lugs, dusting bulb pump, no.7 tweezers and fine dusting brush.

• 4 piece
TH-1932

NEW

$24.95

30m Cable Rolls

RG59 75 Ohm Coax Cable

Wire up your TV antenna with quality coax cable designed for today's DIGITAL TV environment. Available in black or white.

• 30m roll

Black WB-2005 $19.95
White WB-2001 $21.95

FROM

$19.95 ROLL

RG6 75 Ohm Coax Cable

Great for domestic TV & pay TV installations! Austar/Foxtel approved.

• 30m roll
WB-2014

$44.95 ROLL

Heavy Duty Speaker Flex - 30m

High quality speaker cable for connecting speakers to your amplifier. 24/0.20mm figure 8 with trace.

• 30m roll
WB-1709

$24.95 ROLL

Extra HD Speaker Flex - 30m

Convenient and cost effective with polarity stripe to make wiring easier.

• 79/0.2mm figure 8
• 30m roll
WB-1713

$64.95 ROLL

Braided Hook and Loop Loom Wrap

Wraps around your cables and secures them with hook and loop.

1.5m 32mm WH-5654 $14.95
1.5m 51mm WH-5656 $17.95

NEW FROM

$14.95

Note: Cable not included

Multi-Filament Zipper Wrap

Filament zipper wraps to combat the problem of messy cables! Simply insert the cable and do up the zip. Double filament for extra strength and durability.

1.5m 30mm WH-5661 $19.95
1.5m 50mm WH-5663 $29.95

NEW FROM

$19.95

Pre-cut Heatshrink Tubing - Trade Pack

Glue lined heatshrink in an array of sizes to suit all needs - 60 pieces in total. Supplied in see through nylon snap shut case.

• 95mm long
WH-5521

$29.95

50A Anderson® Connectors

Easily adapt or extend your 50A Anderson® connector with the following options. Adaptor includes 300mm cable length. Extension lead includes 5m cable length.

Eye Terminals (shown)	PT-4444 $12.95
15A Cigarette Plug	PT-4446 $14.95
15A Cigarette Socket	PT-4448 $14.95
2-Way Splitter	PT-4442 $29.95
5m Extension	PT-4440 $64.95

NEW FROM

$12.95

Jaycar Electronics
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Kits 4 Kids

Robotics

Remote Control Robot Kit

Includes a collection of components ready to assemble, once complete you will have a fully remote controlled robot unit.

- Suitable for ages 8+
- Requires 6 x AAA batteries in total

KJ-8952 **WAS $29.95**

$24.95
SAVE $5

Give a Jaycar Gift Card for Christmas

8 in 1 Solar Educational Kit

Construct up to 8 different kits (car, riverboat, octopus, spaceship, solar LED, robot, windmill & space alien). The finished projects are solar powered, but can also be powered by the light from a household 50W halogen light.

- Suitable for ages 3+

KJ-8925

$29.95

In store ONLY. Limited stock. Not available online.

Asuro Programmable Robot Kit

Asuro is a kit developed at the German Centre for Air and Space Travel for an autonomous multi-sensor robot. It has two odometers and several display elements. The supplied duplex infrared interface permits wireless programming, as well as a remote control with a PC. The "brain" of the robot is a RISC processor that also permits the processing of complex programs. This is not a kit for the faint-hearted! Some soldering required.

- Suitable for ages 14+

KR-3120 **WAS $79.95**

$69.95
SAVE $10

3 in 1 All Terrain Tracked Robot

A robust all terrain tracked robot kit with detailed instructions included. Comes with 6 terrestrial tracks/crawlers. Can be reconfigured to operate as a gripper, rover or forklift type mechanism. Electric motors included.

- Suitable for ages 13+
- Requires 4 x AA batteries

KJ-8918 **WAS $49.95**

$34.95
SAVE $15

Robot Arm Kit with Controller

Capable of 5 separate movements and can easily perform complex tasks. The arm is supplied as a kit of parts and makes an excellent project for anyone interested in robotic construction. 100g lift capacity.

- Suitable for Ages 12+

KJ-8916

Add computer control via USB to your Robotic Arm
KJ-8917 $34.95

$49.95

Buy KJ-8916 & KJ-8917 for $75
SAVE $9.90

Green Power Kits

6 in 1 Solar Educational Robot Kit

Construct up to six different projects. Everything snaps together for easy assembly.

- Projects: robot, helicopter, plane, windmill, airboat & three wheeler
- Suitable for ages 10+

KJ-8936 **WAS $14.95**

$9.95
SAVE $5

6-in-1 Solar Educational Kit

Build any one of six different projects (windmill, car, dog, plane, airboat, revolving plane). No tools, soldering or glue required. All the parts snap together with spring terminals for the wiring.

- Suitable for ages 10+

KJ-8926

$9.95

Wind and Solar Powered RC Cars

Very simple to build and comes with construction details to explains how alternative energy can generate electricity.

- Suitable for ages 8+
- Car size: 60(L) x 30(W)mm

Wind Powered
KJ-8838
Solar Powered
KJ-8839
Were $14.95

NOW $9.95 ea
SAVE $5

Gifts Under $25

Snap-on Project Kits for Kids

Simple snap together electronic project kits. Both kits are great educational tools with fun bright coloured pieces.

- Suitable for ages 5+

Snap-on Electronic Kit
- 80 snap on projects

KJ-8970

$19.95

Car and Boat Project Kit
- Finished project acutlly moves!
- Requires 2 x AA batteries

KJ-8972

$24.95

NEW

KJ-8970

KJ-8972

Wind Powered Eco-biker

Build this model bicycle rider kit and mount it on the handlebars of your bike. If the wind is strong enough it turns the arms and legs, and generates enough electricity to run the bike's LED headlight!

- Suitable for ages 8+

KJ-8923

Buy 2 for $12.00
Save $7.90

$9.95

7 in 1 Solar Rechargeable Station Kit

Initially assembles into a recharging station and can then be transformed into a truck. Can also build concept car, racer, dump truck, bulldozer or solar powered car.

- Suitable for ages 8+

KJ-8964
WAS $19.95

$14.95
SAVE $5

Remote Controlled Tank Kit

Includes the chassis, 2 x tracks, the hull, a turret, 2 gun tubes, one gun support and all the wheels. Assemble the pieces and you will have a fully functioning tank ready to roll out!

- Suitable for ages 8+

KJ-8950 **WAS $29.95**

$24.95
SAVE $5

Mini Solar Bullet Train Kit

This kit is an excellent way to teach how solar power is used to drive a small motor. Perfect for train enthusiasts!

- Suitable for ages 10+

KJ-8929

$9.95

Buy 2 for $12.00
Save $7.90

In store ONLY. Limited stock. Not available online.

To order call 1800 022 888

www.jaycar.com.au

Savings off original RRP. Limited stock on sale items

Kits - Build Them

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Speed Control Kit for Induction Motors

Ref: Silicon Chip Mag April/May 2012

An advanced project for an experienced constructor.

Control induction motors *up to 1.5kW (2HP) to run machinery at different speeds or controlling a pool pump to save money. Also works with 3-phase motors. Full form kit includes case, PCB, heatsink, cooling fan, hardware and electronics.

KC-5509

$249.00

*Does not work for motors with centrifugal switch

10A Deluxe Motor Speed Controller Kit

Ref: Silicon Chip Mag April 2009

Allows the speed of a 240VAC motor to be controlled smoothly from near zero to full speed. The advanced design provides improved speed regulation & low speed operation. Also features soft-start, interferences suppression, fuse protection and over-current protection. Kit supplied with all parts including pre-cut metal case.

Note: Not for use with induction motors.

KC-5478

$99.95

USB Port Voltage Checker Kit

Ref: Silicon Chip Mag July 2013

An easy way to test a USB port to see if it is dead, faulty or incorrectly wired to help prevent damaging a valuable USB device you plan to connect. Voltage is indicated using three LEDs. Kit supplied with double sided, soldermasked and screen-printed PCB with SMDs pre-soldered, clear heatshrink, USB connectors and components for USB 2.0 & 3.0.

• PCB: 44 x 17mm

KC-5522

$29.95

Garbage and Recycling Reminder Kit

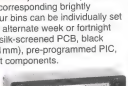
Ref: Silicon Chip Mag January 2013

Easy to build kit that reminds you when to put which bin out by flashing the corresponding brightly coloured LED. Up to four bins can be individually set to weekly, fortnightly or alternate week or fortnight cycle.Kit supplied with silk-screened PCB, black enclosure (83 x 54 x 31mm), pre-programmed PIC, battery and PCB mount components.

• PCB: 75 x 47mm

KC-5518

$29.95



The 'Flexitimer'

Runs on 12-15V DC and switches the on-board relay once or repeatedly when the switching time is reached. Switching time can be set between 7 seconds and 2 hours in fixed steps.

• PCB size: 74 x 47mm

KA-1732

$19.95

Give a Jaycar Gift Card for Christmas

Automatic Headlights Kit for Cars

Ref: Silicon Chip Mag October 2013

Like modern cars, this kit will turn your car headlights on automatically if you forget to turn the lights on when it gets dark. It can also turn the lights off when you park to avoid a flat battery. See website for full features.

• Kit supplied with double sided, solder-masked and screen-printed PCB, die-case cast, buzzer and electronic components. Cabling not included

KC-5524 *DUE MID DECEMBER.*

NEW

$59.95

Ultrasonic Antifouling Kit for Boats

Ref: Silicon Chip Mag September/October 2010

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. Standard unit consists of control electronic kit and case, ultrasonic transducer, potting and gluing components and housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers. Basically all parts supplied in the project kit including wiring.

• 12VDC
• Suitable for power or sail
• Could be powered by a solar panel/wind generator
• PCB: 104 x 78mm

KC-5498

Also available Pre-built:

Dual output, suitable for vessels up to 14m (45ft) YS-5600
WAS $899.00 NOW $799.00 SAVE $100.00

Quad output, suitable for vessels up to 20m (65ft) YS-5602
WAS $1199.00 NOW $999.00 SAVE $200.00

$249.00

Includes Epoxies

Battery Saver Kit

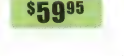
Cuts off the power between the battery and load when the battery becomes flat to prevent the battery over-discharging and becoming damaged. Suits SLA, Li-ion, Li-Po and LiFePO4 batteries between 6 to 24V. Uses very little power (<5uA) and handles 20A (30A peak). Supplied with double sided, soldermasked and screen-printed PCB with SMDs pre-soldered (apart from voltage setting resistors) and components.

• PCB: 34 x 18.5mm

KC-5523

NEW

$29.95



Short Circuits Series

Learning electronics is fun with this short circuits books with their own series of construction projects. All books are geared towards specific levels of electronics knowledge. Size: 205 x 275mm.

Short Circuits - Volume I

Acts as an introduction to electronics, NO previous knowledge of electronics is needed.

• Softcover - 96 pages

BJ-8502

$9.95

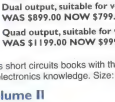
Short Circuits - Volume II

Assumes the constructor has the basic skills and knowledge of electronics. It contains 20 exciting projects and introduces the novice to soldering etc.

• Softcover - 148 pages

BJ-8504

$12.95



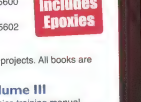
Short Circuits - Volume III

This is the definitive electronics training manual. After the constructors have built any or all of the described projects, there is no reason why they would not be able to tackle any of the construction projects published in the electronis magazines.

• Softcover - 128 pages

BJ-8505

$14.95



See www.jaycar.com.au/shortcircuits for list of projects

Happy Holidays

Jaycar — Better, More Technical

Sign-Up NOW !!!

The Jaycar Rewards programme will entitle you to accumulate one point with every dollar spent* at any Jaycar Store* and be rewarded with a $25 Rewards Cash Card once you reach 500 points.

Register online today by visiting

www.jaycar.com.au/rewards

*Conditions apply, company stores only and only available for retail transactions in Australia and New Zealand. See website for full terms and conditions.

Gifts Under $100

Portable Guitar Practice Amp

Feature packed with 32 built-in live rhythm drum patterns, volume, gain, distortion, overdrive, tone controls and AUX-IN jack.

- Headphone jack for private practice
- Built-in E-string tuner
- 2W Mono speaker
- Requires 1 x 9V battery for up to 8 hours play
- Size: 180(L) x 90(W) x 155(H)mm

CS-2553 **WAS $99.00**

$79.00

SAVE $20

In store ONLY. Limited stock. Not available online.

Turntable with Speakers & Audio Output

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Pi NoIR Raspberry Pi Camera Module from RS

Into the Raspberry Pi? Here's a tiny camera module specifically for the Pi. It was developed for diverse applications including those requiring night vision (eg security and monitoring nocturnal animal behaviour), hyperspectral imaging, astronomy, and paranormal investigation. Pi NoIR is capable of taking still photos with a resolution of 2592 x 1944. The tiny module, which measures just 20mm x 25mm x 9mm, can also record up to 1080p HD videos at 30 frames per second, allowing users of Raspberry Pi models A and B to build video applications. The board will plug into the currently unused CSI pins on the Raspberry Pi, using the I²C interface for control.

To get started with Pi NoIR, users will need a Raspberry Pi board, an SD card with OS installed and a battery pack or power supply. Optional extras include an infrared lamp, a Raspberry Pi camera stand, and various cables for HDMI, VGA and Ethernet connectivity. All components are available direct from RS stock.

Contact:
RS Components
25 Pavesi St, Smithvield NSW 2164
Tel: 1300 656 636 **Fax:** 1300 656 696
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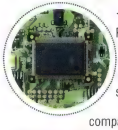

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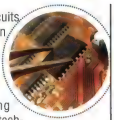

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SERVICEMAN'S LOG

Servicing: variety is the spice of life

Dave Thompson*

You have to be versatile to survive in the servicing business, which is why I'm never reluctant to take on odd-ball jobs. They not only help pay the bills but also give me a break from the often routine computer jobs.

I'VE TALKED BEFORE about the need to diversify a technical support business if the serviceman wants to stay up with – or better still, stay ahead of – the rest of the field. The reality is that keeping up with current best practice can be demanding and many servicemen spend a lot of their time up-skilling in order to remain competitive. It's also necessary to ensure they can competently handle anything that comes through the workshop door (within reason, of course).

Car mechanics are a classic example, given that the car repair field has changed significantly in the last 20 or so years. Gone are the days when all you needed were a few spanners, a screwdriver and a rag to be able to repair pretty much any vehicle on the road. These days, you need an array of specialised (and often expensive) tools and a broad knowledge of the many different systems used in the modern motor car. Those who haven't kept up with these changes will have trouble coping with anything but the most basic repairs.

In my own business, I've never been shy about taking on new challenges. I've also never been shy about turning down work not directly related to my field of expertise if I don't think I'm the person for the job. The trick here is to know my limitations; I don't know everything about everything so if I consider I'm not up to providing a professional level of service for a job, I'm not afraid to say "no".

~CAR MECHANICS ARE A CLASSIC EXAMPLE...

Oddball jobs

Recently, a situation arose that has become fairly common in post-quake Christchurch. As part of my service, I usually carry the customer's hardware out to their car. And on this particular occasion, when I placed a computer I'd repaired on the back seat, I spied several other electronic devices sitting there.

When the client noticed me noticing his gear, he asked me half-seriously if I serviced those devices as well and if not, did I know someone who did. Lately, I've encountered several people doing the same thing – that is, lugging several dead electrical/electronic devices around and asking others if they know someone who can fix whatever it is they have.

This is happening because so many appliance repair companies have now disappeared due to the quakes and former customers no longer know where to go for repairs. What's more, the insurance companies, which took a real pasting after the earthquakes, are tightening their belts. More than ever, they are now demanding detailed assessments and written reports to determine if any given device is worth repairing and if it is, how much it might cost.

It's ironic how things work out; after the quakes, many people assumed that those of us in the computer repair business would be swamped with customers demanding new machines and wanting their office networks rewired. However, this imagined glut of work never materialised, driving many service businesses out of the game altogether.

In my case, necessity really is the mother of invention, which is why I now consider taking on repair work that I haven't done in the past and why I found myself with a few rather odd-ball jobs sitting on the incoming shelf.

Trail camera

The first of these oddball jobs was a device commonly called a "trail" or "hunter's" camera. These are basically rugged, weatherproof, set-and-forget digital cameras with motion sensors and night-vision technology and are typically used to monitor animal activity at trap locations, remote hunting grounds and game trails.

This particular model boasts a rubberised hard-plastic case with leaf-pattern-camouflage and has an array of infrared illuminating LEDs which take up the front half of the case above the lens aperture and PIR sensor. It's battery-powered (4 x D-cells) and can

Items Covered This Month

- Hunter's camera and an odd-ball fridge
- Palec M-52 multimeter resurrection

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be set to take photos, video or a burst sequence of still photos, with the captured data stored on an SD memory card (accessible through a flexible rubber flap in the base of the unit).

The camera also has a multi-programmable timer which allows it to be set to take any combination of video and stills at various times of the day or night. In addition, the PIR sensor (which is both height and width-adjustable) can be used to trigger the camera's recording function by detecting nearby movement.

The owner used this and two other identical cameras on his hunting trips, setting them up to record deer movements on various trails. With their contoured cases, they can be easily cable-tied to a tree or attached to a standard tripod using one of two built-in mounting points.

This type of camera retails for around $300, so I'd be a bit paranoid about leaving such a device out in the woods for fear it would go walkabout. However, because it's camouflaged, it would be very hard to spot when well-placed, unless someone was specifically looking out for it.

Unfortunately, this particular camera had "just stopped working" and its owner wanted to either repair or replace it, depending on the problem.

Troubleshooting

The first thing to try would be new batteries. The client couldn't remember when he'd last replaced them so I opened the battery compartment to check the state of things there. When I did this, I could immediately see a serious problem; there were pools of leaked battery "juice" throughout the moulded plastic bays.

That didn't bode well and when I pulled the batteries out (wearing gloves and eye protection because this stuff is nasty), my fears were confirmed. The batteries had leaked badly and the liquid had gone everywhere. In fact, two of the screws inside the battery bay were that corroded I couldn't engage them sufficiently with a Phillips-head screwdriver to undo them.

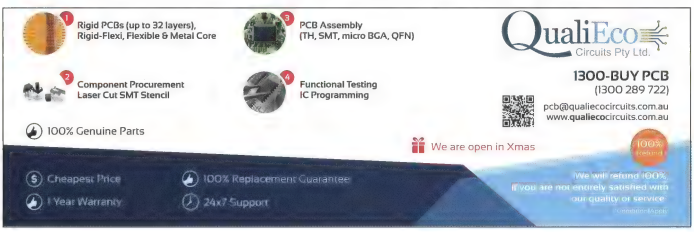
I removed whatever screws I could in the normal way and then carefully drilled out the two I couldn't budge in order to split the case. Once opened, the true extent of the damage was obvious. Much of the circuit board was covered with brown sludge and many tracks and surface-mount components were now fuzzy green outlines of the original parts. So at that stage, it wasn't looking too hopeful.

The first thing to do was clean everything up as best I could. This was done by scrubbing the affected areas using an old toothbrush and a 50/50 water and vinegar mix in a plastic spray bottle. A tray of clean water placed on a heavy plastic bag made an excellent cleaning bath and the bag also kept the majority of the sludge off my workbench during this procedure.

I also used a clear plastic full-face shield because brushing is a messy business and I didn't want any of this stuff near my eyes. Judging by the number of brown spots on the face shield after I'd finished, it was a sensible precaution to wear it. The smell of the sludge alone was bad enough and I could almost taste the toxicity in the back of my throat as I cleaned it up (my solder-fumes fan came in handy here was well).

Having completed the cleaning, I could then assess the full damage to the board. Several tracks were affected and some were missing altogether. The pads of a couple of surface-mount transistors and several other components also appeared to be somewhat corroded but everything measured OK in-circuit. I couldn't find any circuit diagrams anywhere for these cameras, so any troubleshooting that required schematics simply wasn't going to happen.

Given the circumstances, the best I could do was replace the burned and



damaged PCB tracks with light-gauge insulated hook-up wire, before connecting it to my bench power supply to try it out. I wound the current right down and switched the voltage to low-range (0-4V). I then set the voltage to 3V and switched on.

As I gradually wound up the current, things started happening. A small on-board relay chattered as it tried to engage and a power LED lit up faintly. The current drain was as expected, so I turned it off, selected the 4-30V range on my bench supply and set the output to 6V.

At this voltage and with the current stable at about 150mA, I then pushed a couple of buttons and the voltage sagged as the current exceeded the set limit. As a result, I increased the current limit and continued pushing buttons to test the unit. All seemed well, so I turned it off and refocused my attention on the case.

Extracting the corroded screws proved relatively straightforward but the battery bay terminals were a bit more challenging to fix. Two of them had all but dissolved into useless rusting lumps. Fortunately, I make it a practice of keeping the battery contacts if throwing away old toys or other battery-operated gear for just such occasions.

I soon found a couple that were fairly close to the originals in terms of size and shape. A little tweaking using some long-nosed pliers and a small grinder soon had the new terminals sitting in place and I then soldered the connecting leads to them.

Finally, I reassembled the PCB into the case and found a couple of screws to replace the ones I'd drilled out. Four new batteries completed the restoration and it was now all fixed and ready to "shoot" game once more.

Of course, it may very well fail at some point further down the track (no pun intended!) due to corrosion. However, it was working for now so its owner could at least get some more use out of it.

Odd-ball fridge

The second odd-ball appliance I recently took on was a small fridge. This wasn't one of those so-called "bar" fridges but an even smaller novelty-type fridge that ordinarily wouldn't be worth repairing.

This one was different in that it was branded with a well-known whiskey maker's motif and thus was almost a collectible to the right person. So regardless of what it was worth in dollar terms, it had sentimental value to the owner and he wanted to know if it could be fixed.

According to its owner, the problem was that it no longer cooled anything down. When plugged in, a fan buried somewhere underneath the unit spooled up and the little LED lamp inside the fridge came on when the door was opened but that was about it.

I left it running for about 15 minutes but after that time, it was just as warm inside as it was outside. So the customer was right – it wasn't cooling down.

This type of fridge doesn't employ complicated heat exchangers, compressors and ozone-depleting gases to achieve its cooling but instead uses an extremely simple (but very clever) thermoelectric system that is surprisingly effective in coolers of this size. These systems exploit what is known as the Peltier effect (after Jean Peltier who discovered it in the 1840s), whereby passing a current through the junctions of certain materials either cools or heats those junctions, depending on the direction of the current flow.

While early thermoelectric-based refrigeration systems were written off as inadequate novelties, subsequent advances in the manufacture of increasingly efficient Peltier modules has reversed that situation. This type of refrigeration is now quite common and some high-end cars now include cooler compartments based on these devices, to keep one's bubbly at just the right temperature for those "apres-ski" picnics.

Pulling the fridge apart was no challenge whatsoever. Removing four large PK screws was all it took to remove the base and reveal the workings of the fridge, the process taking no more that just a few minutes. There wasn't much to look at; a computer-sized fan sat on a rather crude aluminium heatsink and this in turn was screwed down onto the Peltier module itself.

The cause of the problem was immediately apparent – a red wire, which I assumed should have been attached to the Peltier element, floated free. My guess was that simply reattaching it would get the fridge working but there was just one problem – the wire didn't have any obvious terminal to connect to on the element and on closer inspection of the still-intact black cable, it looked like it was terminated directly into the Peltier element itself.

This type of element looks like two small, thin squares of white ceramic-type material sandwiching rows of silver-coloured core material. Red and black wires normally exit the matrix from opposite sides of the element and

these connect to a DC power source. Depending on which way around it's wired, you can have the element heating or cooling. In this case, it was obviously wired to cool things down. As the module cools, the heatsink temperature also drops and the fan then forces the resulting cold air through the walls of the fridge.

The Peltier element in this fridge measured 40 x 40mm and going by the numbers printed on it, is rated at about 30W, making it a mid-range unit. The problem, as mentioned, was that I couldn't reattach the red wire to the element because there was nothing left to connect it to. The silver core material looked almost powdery where the wire attached and solder certainly wouldn't stick to it, nor was there anything in the element to crimp a wire to.

No matter; replacement elements are surprisingly inexpensive and readily available at the usual hobby electronics outlets. A quick reference to one such company's website and a trip down-town to pick one up was all it took to find a replacement for the damaged module. Installation was simple; remove the old element, insert the new one with some new heatsink compound and tighten everything back down.

I also cable-tied all the flying leads tightly onto adjacent parts or case mouldings to minimise the chance of vibration and possible future wire breakage.

This time when I powered it up, it only took a few minutes to confirm that it was cooling down, so it turned out to be a very simple and inexpensive fix. Not only was the client happy to have his chintzy novelty bar-fridge back in action but it also gave me a break from the usual computer-centric fixes I usually fill my days with.

After all, variety really is the spice of life. Admittedly, I'm not ready to put a "Dave's Fix-it Barn" sign up over the workshop door just yet but I'm happy to take on some of these oddball jobs in order to make a decent living.

Resurrecting A 50-Year-Old Palec M-52 Multimeter

The Australian-made Palec multimeters from the 1950s were top-notch instruments renowned for their accuracy and reliability, at least by the standards of the day. J. G. of Carlton North, Victoria recently rescued and restored an old Palec M-52 to working order. Here's his story . . .

I love fossicking around for treasures in junk shops. Recently, I came across a Palec M-52 multimeter that had seen better days.

The Australian company Palec (Paton Electric) was established by Fred Paton in 1938 and had a reputation for high quality. The M-52 had a spring-loaded jewel-bearing movement, relay-based overload protection, range steps of 1, 3 & 10 and could measure AC currents up to 30A.

Touted as a "top-of-the-line" model, it was advertised in the April 1958 issue of *Radio Television and Hobbies* for £43 ("terms available"), an amount equivalent to somewhere between $500 and $1000 in today's currency.

The specimen in the junk shop was so deeply encrusted in dust that its meter face was barely visible. In addition, the "semi-hard" rubber case was beginning to perish but for $68, I just had to snap it up.

After a preliminary clean-up to remove half a century of grime, the first task was to see if there was any hope of restoration. A quick check revealed that the meter coil was intact. However, when I tested the meter on the 10V scale, the needle swung to midway and stuck there.

I removed the front cover of the movement and found that the pointer's counter-weight was fouling the magnet, suggesting that the meter had been dropped heavily. After gently bending the counter-weight back into position, the needle moved freely and there was no other sign of damage. When I placed the meter on its side and tilted it forwards and backwards, the needle stayed exactly at zero, indicating that the movement was correctly balanced.

A preliminary check of the DC voltage ranges showed that the calibration was still reasonably accurate so the next step was a look inside. Fortunately, the batteries had been removed and although the battery clips were slightly corroded, the interior was in remarkably good condition. There was a sensitive "hair trigger" latching relay for overload protection, some rather ancient capacitors and composition resistors, and a current transformer for AC current measurements. Unfortunately, I was unable to find a circuit diagram on the web and the question now was what should be done first?

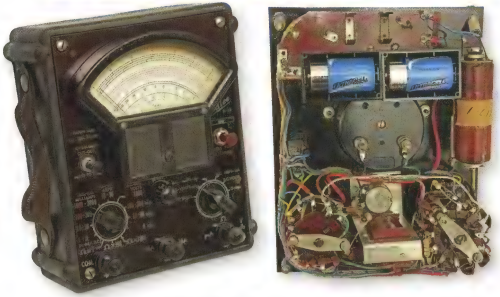
I decided to start with the red push-button selector switch which was very erratic when switching between the x1 and x3 ranges, no doubt due to dirty contacts. Cleaning up with DeOxit® spray helped, after which the contacts were lightly burnished using a fine diamond nail file to give reliable operation.

What about the internal components? Composition resistors are notorious for "going high" in value and a few measurements showed that a 1kΩ resistor was now about 2.5kΩ, while an 800Ω resistor was now about 1kΩ. In the end, I decided to replace all the composition resistors with modern carbon-film types.

There were also numerous other resistors painted in red enamel, which appeared to be precision types. Their values were difficult to read and I decided to leave them alone. I also left the numerous wirewound resistors alone, as they were likely to be OK.

Behind the battery board were two original Ducon capacitors: an 8μF 500V electrolytic and a 0.5μF 500V waxed-paper type. It seemed likely that the electro would now be dried out and the paper capacitor leaky, so I replaced them both. However, when I subsequently checked them, both

This photo shows the old Palec M-52 multimeter before restoration. It was covered in dust and grime and had several internal faults.



These photos show the Palec M-52's appearance after cleaning and restoration. The original diodes in the rectifier had to be replaced with Schottky diodes to get the AC voltage ranges working (see text).

had minimal leakage and were close to their nominal capacitance, much to my surprise.

In fact, the ESR of the 50-year old electro was 0.75Ω, which is well within current specifications. I wonder if current electros will fare this well in 50 years!

My next step was to check how the meter performed on the DC voltage and current ranges. I was pleasantly surprised to find that these all worked perfectly and were within about 3% of the correct values at full scale when compared with an Avo Model 8 analog meter and a Digitech digital meter.

The resistance ranges were next. The M-52 uses two 1.5V cells for the low-ohms ranges and a 30V battery for the highest ohms range. However, the clips were designed for batteries that are no longer made so I replaced the low-voltage clips with plastic holders for C-type cells. When I subsequently tested it, I found that I also had to replace the 800Ω resistor in series with the ohms-adjustment potentiometer with a 470Ω resistor before I could correctly set the unit to "zero ohms" at full scale.

After that, the low-ohms ranges seemed to function correctly and resistance readings at mid-scale were within 3% of the correct values. Unfortunately, I wasn't able to find a suitable 30V battery for the Ω x 1000 range. The meter's junior brother, the Model M-32, uses an external 30V series source for this range, so I decided to adopt the same approach. As a result, I joined the clips for the 30V battery to allow this scheme to be implemented.

The meter's AC ranges were totally dead and I assumed that the rectifier diodes were the most likely cause of this fault. However, when I looked for these diodes, they were nowhere to be found. Eventually, I did find the rectifier which was hidden inside a small circular plastic container located underneath one of the selector switches.

A Google search revealed that multimeters from this period used specially-designed copper-oxide rectifiers. These consisted of a stack of copper and copper-oxide discs connected in a full-wave bridge configuration and sealed in a plastic case. No wonder I couldn't find them when I first started looking!

Four fine wires emerged from the rectifier but which was which? After making a drawing of the connections, I unsoldered all four. If all four diodes were intact, the leads would be easy to identify simply by measuring the forward and reverse resistance. Unfortunately, as anticipated, the rectifier was indeed faulty and that meant I now had to identify the leads by some other method.

The first clue was a red spot that seemed likely to be the positive output (ie, the diode cathodes). In addition, two white wires seemed to be the likely candidates for the AC input, because their polarity would be irrelevant. So, if the logic so far was correct, the remaining wire had to be connected to the anodes.

The resistance between the white wires was 0Ω in both directions, indicating that at least two diodes were short circuited. Fortunately though, the resistance between the wire with the red spot and the two white wires was higher and dependent on the direction of the test current. These resistance tests clearly showed that the red spot indicated a cathode.

Radio & Hobbies to the rescue

So I needed to replace the rectifier diodes but I was unknowingly getting out of my depth. Fortunately, I was rescued by a beautifully-written article by Neville Williams titled "How To Build An AC/DC Multimeter", as published in the June 1944 issue of "Radio and Hobbies" (it's on the Radio, TV & Hobbies DVD). Until I read Neville Williams' article, I had no idea of the subtle problems and ingenious solutions that went into AC voltmeters at that time.

It was (and still is) standard practice to calibrate meters in terms of the RMS (root mean square) value of a sinewave voltage. The RMS value of a sinewave is the peak value divided by √2, or 0.707 times the peak value. However, d'Arsonval moving-coil meters respond to what is termed the "average" value of a sinewave, which

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Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

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Please be sure to include your full name and address details.

is twice the peak value divided by π, or 0.637 times the peak value.

From this, it follows that if a meter uses the same multiplier resistors for both the DC and AC voltage ranges, the scale for the equivalent AC range will be $0.637 \div 0.707 = 0.9$ of the equivalent DC range. Alternatively, if the AC and DC ranges are to have the same full-scale mark, the sensitivity of the movement for the AC ranges has to be increased.

d'Arsonval movements of the time generally had a full-scale sensitivity of 1mA (giving a loading of 1kΩ/V). However, in order to use the same full-scale mark for both AC and DC, multimeter movements often had a full-scale deflection of 0.9mA which was used for AC measurements. For DC measurements, a shunt of nine times the coil resistance was added to give a full-scale sensitivity of 1.0mA. In this way, the same multiplier resistances could be used for both the AC and DC ranges.

The Palec M-52 and its M-32 little brother both used this strategy.

Diode characteristics

All diodes have highly non-linear resistance characteristics, with the resistance greatest at low current (or low forward voltage). This means that measurement errors will be greatest at low voltages and AC meter scales had to be specially calibrated to take this into account.

Copper oxide rectifiers are no longer available and that meant I would have to replace them with something else. But could replacement diodes with similar characteristics be found, so that the meter calibration would still be accurate?

As a first step, I decided to try 1N914 silicon diodes in a bridge configuration, simply to test my logic. When I applied an AC voltage, the needle swung up most gratifyingly, verifying that I had guessed the connections correctly. Unfortunately though, the errors were enormous which was to be expected. At 4V, the readings were 25% too low and at 1V they were 57% too low. But at least I had guessed the bridge connections correctly!

My first thought was that the errors reflected the well-known forward voltage drop of silicon diodes. Germanium diodes have a lower forward voltage than standard silicon diodes (0.2V versus 0.6V), so I tried substituting 1N34 germanium diodes. The results were nearly as bad – the error at 3V input was -20%; at 1.5Vs input it was -25%; and at 1.0V it was -17%.

The big problem here is that the maximum current through the diodes at full-scale deflection is only 0.9mA. It was time to do some basic tests so I set up a DC power supply with a 100kΩ series resistor and measured the forward voltage versus forward current for a number of different diodes. The results were interesting.

The "knee" point (ie, where saturation begins) for silicon diodes was about 0.25mA and 0.55V. Even assuming that the forward characteristic up to this point is linear (which it isn't), this would correspond to a resistance of about 2.2kΩ. The coil resistance of the meter was measured at 92Ω, so the error would be substantial, in accord with the observed results.

I had no detailed information about the forward characteristics of the copper oxide rectifier used in the M-52 but the evidence clearly indicated that I needed diodes with a low saturation voltage and also low forward resistance in the region prior to saturation. Schottky diodes have a much lower saturation voltage than silicon diodes, typically 0.2-0.3V, so would they fill the bill?

I tried several different Schottky diodes, including 1N5822, 1N5819 and BAT46/48. Of these, the 1N5819 seemed to best fit the requirements. When put to the test, the 1N5819 was nearly a perfect substitute for the copper oxide diodes.

Perhaps this is not so surprising, since the copper/copper-oxide interface can be regarded as a primitive form of Schottky diode. However, I was a little surprised to find that while the higher-power 1N5822 Schottky diodes have virtually identical forward characteristics, they gave significantly greater errors. Using the 1N5819 diodes, the AC voltage readings were close to perfect (within 3%) from 240VAC (the highest I was able to measure) down to 0.4VAC and they were only 10% high at 0.2VAC.

The only function of the meter that I have not yet been able to resurrect is measurement of AC current. The instructions for the M-52 state that the overload protection relay is not functional on current ranges. I was unable to find a circuit diagram but it appears that the secondary winding of the current transformer is open circuit. Unfortunately, it's unlikely that this can be fixed.

It's a tribute to Fred Paton that he produced an instrument of such quality that it required only minimal repairs and retained high accuracy for more than half a century.

References: (1) Neville Williams – "How To Build An AC/DC Multimeter"; Radio and Hobbies, June 1944. (2) Neville Williams: "Fred Paton; From Screwdriver & Pliers To Purpose-Built Test Equipment"; Electronics Australia, December 1993. **SC**

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More reception modes for the SiDRADIO & SDRs

By JIM ROWE

Wondering if there's anything else you can do with your software defined radio (SDR) set-up using a DVB-T dongle – besides receiving AM, NFM, WFM, CW, SSB and DRM? Other applications are becoming available all the time. Already there's one that lets you receive DAB+ digital radio and another to receive some of the many different types of narrowband digital mobile radio (DMR).

MOST DVB-T dongles come with bundled software that allows them to be used for receiving SDTV and HDTV signals, as well as DAB+ digital radio and conventional FM signals. But if you're using a dongle as part of an SDR set-up, it's a bit messy to also use it for DTV/DAB+ reception on the same PC. That's because you have to disconnect it and plug it into a different USB port from the one you are using for the SDR.

This is necessary because the USB driver for DTV/DAB+/FM reception using the bundled software is quite different from the one that Zadig installs for use with SDR software. Fortunately, there is a way baround this problem.

What we are going to do here is show you how to get DAB+ reception while leaving the dongle as part of an SDR configuration (or even as part of the SiDRADIO described in the October and November 2013 issues). In other words, you will no longer have to unplug the dongle and plug it into a different USB port. All you have to do is install and run some additional software.

Now it's true that most of the DVB-T dongles use the Realtek RTL2832U COFDM demodulator chip, which already has internal 'hardware' to decode DAB+ digital radio signals. In fact, this function is used by the bundled software that comes with the dongles.

However, as yet, the programmers working on SDR apps (applications) haven't discovered how to make use of this internal hardware of the RTL-2832U chip. Instead, they use the RTL-SDR driver (installed by Zadig) to switch the chip into its 'radio' mode. In this mode, it simply passes on the quadrature (I and Q) samples coming from the dongle's tuner chip and sends them to the PC via a USB cable. It's here that the SDR application software (SDR#, ADSB#, Dream or whatever) does the decoding/demodulation.

Eventually, someone is bound to work out how to make use of the RTL2832U chip's 'internal decoding hardware' for DAB+ reception and more. But until then, you're going to have to use the 'software decoding' approach, if we want to receive DAB+ transmissions with dongle-based SDRs such as the Silicon Chip SiDRADIO.

TABLE 1: CURRENT VHF BAND III CHANNELS USED FOR DAB+ DRMTs IN AUSTRALIA

METRO AREA	CHANNELS USED
ADELAIDE	9B, 9C
BRISBANE	9A, 9B, 9C
MELBOURNE	9A, 9B, 9C
PERTH	9B, 9C
SYDNEY	9A, 9B, 9C

CHANNEL	CENTRE FREQUENCY	BANDWIDTH
9A	202.928MHz	1.536MHz
9B	204.640MHz	1.536MHz
9C	206.352MHz	1.536MHz

NOTE: ALL OF THESE TRANSMISSIONS ARE VERTICALLY POLARISED

DRMT = DIGITAL RADIO MULTIPLEX TRANSMITTER

Receiving DAB+

As luck would have it, a public domain software package which allows DAB+ signals to be received using a DVB-T dongle-based SDR has been made available in the last few months. Called "SDR-J" and released by Dutch programmer Jan van Katwijk, the latest version (V0.96 at the time of writing) is available as a free download from his website at www.sdr-j.tk

Two versions of SDR-J are available: (1) a Linux version (as a suite of source code files) and (2) a Windows version which consists of a zip file containing the executables. Note, however, that the heavy processing requirements of DAB+ software decoding mean that you need a relatively modern computer to run it. Also, the Windows version is currently only suitable for 64-bit versions of Windows 7 or Windows 8.

If you're running a 32-bit version of Windows, you'll still have to use your dongle's bundled software for DAB+ reception – at least for the time being.

Assuming you're running a 64-bit version of Windows, you might want to try downloading and installing SDR-J V0.96 to see how it performs. While you're downloading the software, you should also download Jan van Katwijk's user manual from www.sdr-j.tk/dab-manual.pdf

As mentioned, the software comes

as a zip file. To extract the files, you have to run ***dabreceiver.exe***. This should install everything 'ready to go' and you'll find a shortcut icon on your desktop labelled "DAB RADIO".

When you double click this icon, you'll first see a command line dialog box open up – just like the one shown at the top of Fig.1. This box will display the actions of SDR-J's software 'engine' as it proceeds. After a short time, it will be joined by a second window similar to the lower one in Fig.1. This is the control panel for SDR-J, although both it and the command line dialog box are displayed all the time that SDR-J is running.

To begin using SDR-J, check the four rectangular buttons at lower left in the control panel window, just below the black 'constellation' display window at upper left. Look first at the button at far left and if it is not displaying "dabstick" as shown in Fig.1, click on the associated down arrow and select "dabstick" from the drop-down menu.

Next, move along to the third button and confirm that SDR-J is currently set to look for DAB+ signals in BAND III (again, as shown in Fig.1). If not, click on its down-arrow and select BAND III from the drop-down menu.

Before going further, check that Band III channel(s) are being used for DAB+ broadcasts in your area. At present, DAB+ signals are broadcast only in Adelaide, Brisbane, Melbourne, Perth and Sydney.

Table 1 shows the channels used by the digital radio multiplex transmitters (or DRMTs) for DAB+ broadcasting in these metropolitan areas. Only channels 9A, 9B and 9C are currently being used, with only two of them in use in some of the smaller capitals.

If you find this a bit puzzling, bear in mind that up to 18 different DAB+ signals can be multiplexed onto a single DRMT 'channel' and each channel is 1.536MHz wide. Just how many DAB+ signals are packaged into each DRMT channel block depends on the data bit rate used by each one.

Once you know which DRMT channels are present in your area, you can continue setting up SDR-J. First, click the down-arrow associated with the fourth button at lower left and select the channel you want from the drop-down menu. Fig.1 shows that channel 9C has been selected in our case. This channel carries the ABC and SBS DAB+ broadcasts in Sydney.

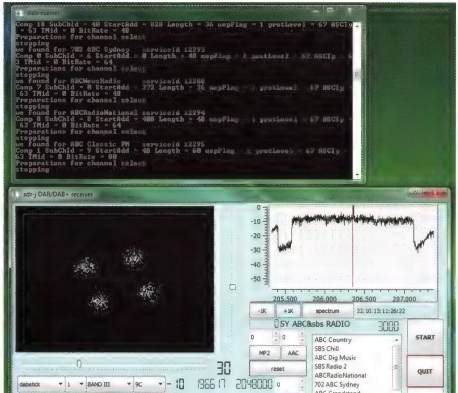

Fig.1: SDR-J first opens up a command line dialog box, followed by a second control panel window. Both are displayed while ever SDR-J is running.

Then click the large START button at centre right of the control panel and SDR-J will start searching for DAB+ signals in the selected channel and you should see each of the signals it finds in the 'list box' just to the left of the START and QUIT buttons.

Fig.1 shows some of the signals found within channel 9C in Sydney in the list box. It also shows the spectrum display that SDR-J has produced for Sydney channel 9C DAB+ multiplex, ie, in the spectrum box at upper right of the control panel window.

Next, look at the long rectangular button at bottom right on the control panel, which initially will probably be labelled "select output". Click on its down arrow and select one of the options from the drop-down menu. In most cases, this will be an audio output device like "Microsoft Sound Mapper – Output" or "Speakers (Realtek High Definition)".

Then click on one of the entries shown in the list box, to select it. You should then see some activity in SDR-J's upper command-line dialog, while it achieves synchronisation with that signal. Finally, after a few seconds, you should hear that signal's audio from your PC's speakers.

And that's all there is to it!

If you want to change to another station in the same multiplex, all you need do is click on it in the list box. After a few seconds delay, you'll then start to hear the audio from that station.

Other DRMT multiplexes

What if you want to search for signals in one of the other DRMT multiplexes in your area? That's also quite easy. All you need do is select the channel ID for the multiplex you want (eg, say 9A or 9B) by clicking on the down-arrow at the end of the fourth button at lower left. SDR-J will then generate a new list of DAB+ stations (ie, the stations associated with that multiplex) in the list box and show a new spectrum display at upper right. Then all you need to do to receive a station is click on its name in the list box, as before

Other controls

What about all of those other controls and displays scattered around SDR-J's control panel? Jan van Katwi-

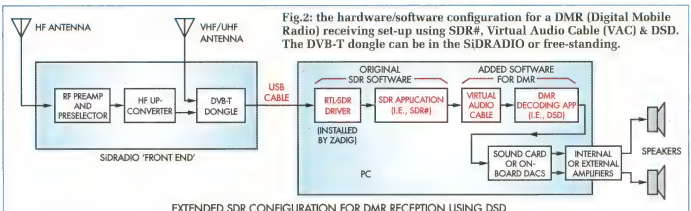

Fig.2: the hardware/software configuration for a DMR (Digital Mobile Radio) receiving set-up using SDR#, Virtual Audio Cable (VAC) & DSD. The DVB-T dongle can be in the SiDRADIO or free-standing.

jk's user manual isn't all that helpful when it comes to many of these, so you will have to work them out for yourself. But some are fairly self-evident if you look at them closely – or at their label, where they have one.

For example, in the lower centre of the control panel shown in Fig.1, you'll see SDR-J's title: "sdr-j DAB(+) 0.96". And below this you can see the name of the station I had tuned to: "ABC Classic FM DAB+", with its programming language and summary shown to the left.

Just above the SDR-J title, you can see two numbers, displayed in 7-segment format: 196617 and 2048000. The first of these apparently indicates the length of the data frames detected in the multiplex signal (it should normally read about 196617, as shown), while the second shows the total bit rate used in that multiplex. The latter always seems to read 2048000, suggesting a total bit rate of 2.048Mbps.

Just above the list box, you can also see the label "SY ABC&sbs RADIO", which is presumably the name of the DRMT multiplex signal itself.

At lower right, just to the left of SDR-J's "Output Select" button, there's a small box displaying a single digit ("8" in Fig.1). Just to its left, there's a label reading "dabstick gain" and if you click on one or other of the small direction arrows on its right, you'll find that the spectrum display moves up or down as the displayed gain digit increases or decreases.

This seems to be the way SDR-J allows you to adjust the RF gain of your DVB-T dongle, for optimum DAB+ reception (presumably "dabstick" is what DVB-T dongles are called in many parts of Europe).

One last suggestion: the row of display boxes at bottom left has fairly cryptic labels, making it difficult to work out their significance unless you're an expert on DAB+. However the "bit rate" label just below the fifth one from the left suggests that it shows the bit rate of the particular signal in the multiplex currently being decoded. In this case, it's showing "80", while the third last line in the command line box above also shows 80 as the bit rate of the ABC Classic FM signal being received at the time.

This means that the ABC uses a bit rate of 80kbps for this signal, which is encoded using the HE-AAC compression codec.

Receiving DMR

OK, so much for using SDR-J to receive DAB+ broadcasts. Now let's take a brief look at yet another application for SDRs based on a DVB-T dongle.

As Kevin Poulter explained in his article on "Narrow Band Digital Two-Way Radio" in the October 2013 issue of SILICON CHIP, professional 2-way radio communications is rapidly making the transition from analog to digital technology. This is because digital encoding offers more efficient use of the spectrum, allowing more users to be crammed into limited spectrum space.

So narrowband 2-way radio is fast becoming "DMR" or digital mobile radio. That may sound simple but the catch is that there are many different digital encoding formats and modulation modes. These can make it quite difficult to receive and decode DMR signals – especially as many of the formats allow for the signals to be encrypted or scrambled for high security communications like those of the military, intelligence services and police.

For example, there's NXDN or Next Generation Digital Narrowband technology, developed jointly by Icom and JVC Kenwood. This allows two 6.25kHz wide narrowband digital channels to be fitted into a single 12.5kHz wide VHF communications channel.

Then there's Project 25 (P25/APCO-25), a suite of digital radio communications formats which were developed in the USA to allow reliable and secure 2-way radio communications within specific federal and state government agencies and between these agencies.

Another variant is the set of protocols developed by the European Telecommunications Standards Institute (ETSI) for professional DMR, or 'PMR'. There's also Motorola's DMR/MOTOTRBO, ProVoice EDACS, and so on.

Fortunately, an open source software package recently became available to allow a DVB-T based SDR setup to receive and decode at least some of this plethora of DMR formats and modulation systems. Called Digital Speech Decoder or "DSD" for short, it can decode the following DMR formats and modulation types (providing they're not encrypted):

- P25 Phase 1
- ProVoice EDACS digital voice
- NXDN – 9600-baud/12.5kHz NEXEDGE and 4800-baud/6.25kHz NEXEDGE/IDAS
- X2-TDMA – Motorola public safety TDMA
- DMR/MOTOTRBO
- C4FM modulation, GFSK modulation and QPSK/LSM modulation

The DSD package can be downloaded from: **http://wiki.radioreference.com/index.php/Digital_Speech_Decoder_(software_package)** The version you'll need in order to run DSD on Windows PCs is currently called "Windows Port With P25/DMR Filter 1.6.0 Beta".

When you download this file, you'll

Software For SDR Applications Using DVB-T Dongles & Where To Find It

A. For basic SDR (AM, WFM, NFM, CW-L, CW-U, USB, LSB, DSB reception) you'll need:

(1) The RTL-SDR driver, which is installed using the installer program Zadig. A compressed file containing Zadig can be downloaded from **sourceforge.net/projects/libwdi/files/Zadig** but note that (a) there are two versions of Zadig, one for Windows XP and the other for Windows 7; and (b) both versions can only be downloaded as compressed files in '.7z' format, so they must be extracted using 7-Zip rather than Winzip.

7-Zip can be downloaded from either **sourceforge.net** or from **www.7-zip.org** but note that it too comes in two versions – one for Windows XP and the other for Windows 7.

(2) An SDR decoding and display application, such as SDR#. This is open source and comes in three separate files – two of which can be downloaded from **http://sdrsharp.com/downloads**, while the third (rtlsdr.dll) must be downloaded from the Osmocom website at **http://sdr.osmocom.org/trac/wiki/rtl-sdr/**

For more information on downloading, installing and using these basic SDR software components, refer to our article in the May 2013 issue of SILICON CHIP.

B. For receiving, decoding and displaying the ADS-B broadcasts from aircraft flying overhead, you'll need:

(1) the RTL-SDR driver which is installed using the installer program Zadig (see item A.1 above).

(2) An ADS-B decoding application like ADSB# or RTL1090. These are both open source and ADSB# can be downloaded from **http://sdrsharp.com/downloads/adsbsharp.zip**

There's also a quickstart guide for ADSB# written by Henry Forte and available as a pdf file from **http://www.atouk.com/wordpress/?p=247** The RTL1090 application can be downloaded from **http://rtl1090.web99.de/**

(3) An ADS-B processing and display application like ADSBScope, Virtual Radar Server or PlaneSpotter. ADSBScope can be downloaded from **http://www.sprut.de/electronic/pic/projekte/adsb_en.html#downloads**; Virtual Radar Server from **http://www.virtualradarserver.co.uk**; and PlaneSpotter from **http://www.coaa.co.uk/planespotter.htm**

For more information on downloading, installing and using these ADS-B software components, refer to our article in the August 2013 issue of SILICON CHIP.

C. For receiving and listening to DRM (Digital Radio Mondiale) signals, and decoding them via RTL-SDR, you'll need:

(1) The RTL-SDR driver which is installed using the installer program Zadig (see item A.1 above).

(2) An SDR decoding and display application such as SDR# (see item A.2 above).

(3) A 'virtual audio cable' program like Virtual Audio Cable (VAC), to direct the digital audio output from SDR# to the input of the DRM decoding application. Virtual Audio Cable can be downloaded from either **software.muzychenko.net/vac.htm** or **download.cnet.com/Virtual_Audio_Cable**

(4) A DRM decoding/receiver application, like DREAM. This open source application can be downloaded from **sourceforge.net/projects/drm/files/dream/** You will also need the precompiled *faad2_drm.dll*, which is used for DRM decoding using the AAC codec. This must be downloaded from: **https://mega.co.nz/#!m5RUHIDQ!SqcGUBSGMFSTAm09XX78RDYRoIJW0T545QQRJ_dFuE**

For more information on downloading, installing and using these software components, see the article in the November 2013 issue of SILICON CHIP.

D. For receiving and listening to DAB+ digital radio broadcasts as described in this article, you'll need:

(1) A PC running a 64-bit version of Windows 7 or Windows 8.

(2) The Windows version of the DAB+ receiving application SDR-J V0.96, developed by Dutch programmer Jan van Katwijk and available free from his website at **www.sdr-j.tk** There's also a user manual for it at **www.sdr-j.tk/dab-manual.pdf**

E. For receiving and listening to digital mobile radio (DMR) transmissions, as described in this article, you'll need:

(1) The RTL-SDR driver which is installed using the installer program Zadig (see item A.1 above).

(2) An SDR decoding and display application such as SDR# (see item A.2 above).

(3) A 'virtual audio cable' program like Virtual Audio Cable, to direct the digital audio output from SDR# to the input of the DMR decoding application (see item C.3 above).

(4) A digital speech decoder application like Digital Speech Decoder (DSD). This is an open source program and can be downloaded from **http://wiki.radioreference.com/index.php/Digital_Speech_Decoder_(software_package)#Downloads**

The version to download for PC's running Windows is currently "Windows Port with P25/DMS Filter 1.6.0 Beta".

(5) The Linux emulation layer cygwin1.dll, which is needed by Digital Speech Decoder (DSD) to run on Windows systems. This can be downloaded from **http://cygwin.com/install.html** by clicking on the link "setup-x86.exe".

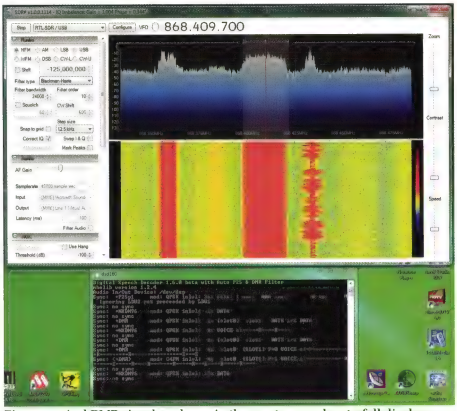

Fig.3: a typical DMR signal as shown in the spectrum and waterfall displays of SDR#. Note that you have to select Virtual Audio Cable (VAC) as the output option (see text) to send the signal to the PC for software decoding.

find it's an executable called **DSD160.exe**, which you can install simply by creating a folder called (say) **C:\Program Files\DSD** and then copying **DSD160.exe** over into it.

Don't try to run it as yet though, because DSD was originally written to run under Linux. As a result this Windows 'port' needs a special Linux emulation program in order to actually run on Windows. This emulation program is an application extension called **cygwin1.dll**, which is part of a suite of programs you need to download and install separately from: **http://cygwin.com/install.html**

All you need to do is go to this page and click on the link **setup-x86.exe** (note: there's another link called **setup-x86_64.exe** but this is not needed for running DSD because the latter is a 32-bit package).

When the Cygwin package has been downloaded and installed (it automatically installs itself in the root directory, usually **C:\cygwin**), you'll find the all-important **cygwin1.dll** file in the **\bin** subdirectory. The next step is to copy this file and paste it into the same folder as DSD itself (ie, **C:\Program Files\DSD**).

Note that this program doesn't communicate directly with your DVB-T dongle via the RTL-SDR driver. Instead, like Dream (the DRM30 decoding application that we looked at in the November 2013 issue of SILICON CHIP), it 'listens' to the digital audio output from your SDR application (eg, SDR#). In order to do this it needs Virtual Audio Cable (VAC), the same miniport digital audio driver used by Dream.

So before you can run DSD, you'll need to download and install both SDR# and VAC – and perhaps even the RTL-SDR driver, if you haven't already done so.

Fig.2 shows the overall hardware/software configuration for a DMR (Digital Mobile Radio) receiving set-up using SDR# plus VAC plus DSD. Note that although this diagram shows the DVB-T dongle fitted inside our SiDRADIO project, the dongle can be free-standing for DMR reception if you wish. That's because you'll only find DMR signals on the VHF and UHF bands at the moment.

Receiving DMR – or trying

The procedure for using your SDR set-up to receive DMR is to first start up SDR# with its digital audio going to your PC's speakers in the usual way. This allows you to search around on the VHF and UHF bands for any likely-looking signals. The best places to start in Australian metropolitan areas are in the 162-174MHz, 470-520MHz and 860-890MHz regions.

By the way, it's a good idea to set SDR# for NFM reception, with a filter bandwidth of either 12.5kHz or 25kHz. Some of the reference information on DMR reception also suggests that the Filter Order should be set to a low figure, such as 10, instead of the default 300 or 400.

Search around on one of these bands using SDR# until you find a signal that looks a bit like that in the centre of the display in Fig.3. If it's a DMR signal, you won't hear any audio at this stage apart from digital noise.

Next click the Stop button at top left in the SDR# dialog and then move down to the Output label in the Audio section below. If you now click on the down-arrow in the text box to its right, you will be presented with a drop-down list showing "Virtual Audio Cable" (VAC) as one of the output options. If you click this option, SDR# will now send its digital audio output to VAC instead of the speakers.

Before you set SDR# running again, fire up DSD by clicking on its icon on your desktop. You'll then see its command-line interface, with the heading "dsd160" – see Fig.3.

Now when you click the "Play" button at top left in the SDR# dialog, you'll probably see some activity in the DSD dialog box as well. Just what you'll see in the DSD dialog depends on what type of signal you've tuned to, its signal strength, the DMR encoding system being used, the modulation mode and whether or not the signals are encrypted/scrambled.

The same qualifications apply as to whether or not you'll hear any audio. In my case, I spent quite a few hours trying to find a DMR signal that I could decode with very little success. I did receive a few seconds of audio on one occasion but that was it.

In fact, my impression is that a lot of the DMR signals nominally available in my area are either encrypted or 'locked up' in trunking systems.

There is an open-source program called "UniTrunker", which is supposed to allow you to decode some kinds of trunked DMR. You can download it from **http://wiki.radioreference.com/index.php/UniTrunker** but I can't say whether or not it's worth the effort. In my opinion, it's for the real enthusiast only and you'd better have a lot of patience! SC

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See Review April 2011

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See Review March 2010

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See Review Feb 2004

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See Review Feb 2003

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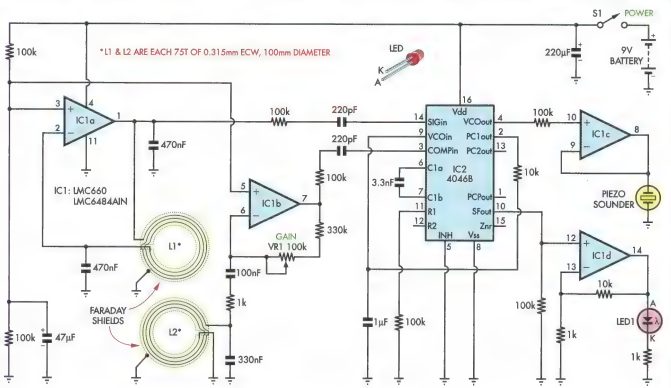
CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Simple 2-coil VLF metal detector

This very low frequency metal detector can sense a large coin from 150mm or larger metal objects at a distance of over 600mm. The detector is built around an LMC660 (or LMC6484AIN) quad op amp and a 4046 phase lock loop (PLL). This is connected to employ the voltage controlled oscillator (VCO) and one phase comparator.

The search head comprises two overlapping coils, L1 & L2. L1 is the transmitter and is driven by an oscillator formed by op amp IC1a. Its 9kHz operating frequency is determined by the inductance of coil L1 and the 470nF capacitor at its pins 1 & 2.

L2 picks up the signal generated by L1 and feeds it to op amp IC1b which has a gain of 430. The outputs of IC1a & IC1b are connected via 220pF capacitors to phase comparator 1 inside the 4046. When the two input signals have the same frequency, the output of the comparator is low.

Any change in the frequency of one of the input signals will cause the output to generate a voltage. This is filtered and fed to the VCO input at pin 9 of IC2. Its frequency is set to 3.2kHz by the components at pins 6, 7 & 11.

The VCO output at pin 4 is fed to op amp IC1c to drive a piezo sounder. The voltage at pin 9 is also available at the pin 10 output of the source follower of the chip. This is connected to 12 of op amp IC1d which has a gain of 11 and drives LED1.

Sensing coils L1 and L2 are identical and wound using 75 turns of 0.315mm (30 SWG) enamelled copper wire on a 100mm diameter former. Each coil is wrapped with insulating tape. A Faraday shield for the coils is then made by wrapping narrow strips of aluminium foil around it. Make sure that each shield has a 10mm gap at one point. A short length of wire should then be connected to the shield which should then be covered with insulating tape.

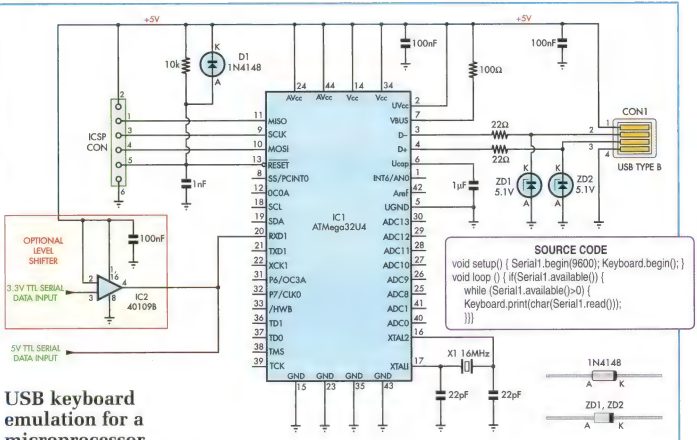
The two coils are mounted on a 250mm diameter circle of 3mm plywood, with a 50mm overlap. This becomes the search head.

To use it, set gain control VR1 midway and place the search head well away from any metal object. With 50mm overlap the sounder should be silent and LED1 should be off. Reduce the overlap of the top coil until you hear a sound from the sounder. This will happen when the coils overlap by about 30mm. Adjust for a low tone for maximum sensitivity.

Now bring a metal object close to the search-head; the piezo pitch should increase and LED1 should light. The most sensitive part of the search-head is the overlapping portion.

The frequency of the sound will depend on the type and size of the object. Large objects, for instance, will cause the VCO to generate a high frequency audio sound of nearly 3.2kHz. Use the gain control if required.

Mahmood Alimohammadi, Tehran, Iran. ($45)




```
SOURCE CODE
void setup() { Serial1.begin(9600); Keyboard.begin(); }
void loop () { if(Serial1.available()) {
  while (Serial1.available()>0) {
  Keyboard.print(char(Serial1.read()));
  }}}
```

USB keyboard emulation for a microprocessor

This circuit converts serial data received from a microprocessor to emulate a USB keyboard 'typing' on a host PC. Serial data is sent into this circuit at 5V TTL signal levels from another processor (the author's project was based on a Raspberry Pi and a barcode reader, but any other processor with TTL serial capabilities will work too, including even the simplest BASIC based variants).

Note that if the 'sending' processor operates with Vcc below 5V (eg, 3.3V), then the optional level-shifting input buffer using one inverter of a 40109 (IC2) is required. If your project produces an RS232 signal, then you would instead need to use a MAX232 to convert the input to TTL serial at 5V first.

The remainder of the circuit is based solely around microcontroller IC1, an ATMega32U4 processor available in a 44-pin QFN or TQFP package. However, most of the components (and a few extras) can in fact be purchased in various forms of pre-built 'breakout' boards from existing retailers.

This is because the circuit is based on the open Arduino platform.

The author made his own custom board to fit directly over the Raspberry Pi's GPIO headers. However, there's no reason you couldn't use an Arduino Micro or Arduino Leonardo, or perhaps use the Freetronics LeoStick available from Jaycar (Cat. XC4266).

Microcontroller IC1 is powered from the USB +5V supply and zener diodes ZD1 & ZD2 clamp the USB bus to 5.1V thereby providing protection to IC1 together with the 22Ω series resistors. IC1's clock speed is set by crystal X1 to 16MHz.

The ICSP header is provided for programming the chip with a suitable Arduino bootloader (if you do roll your own hardware), after which future programming can be undertaken directly from within the Arduino IDE (integrated development environment) without further need for the ISP.

Those who choose to purchase a pre-made Arduino (or clone) won't need the ICSP at all, as their microcontrollers will come preflashed with the bootloader (note exception below).

The entire source code is in the accompanying panel (above). After passing this code into the Arduino's compiler software and building, the resulting hex file can then be uploaded into IC1.

Once programmed, the circuit will operate so that any serial data received on IC1's UART RX input (pin 20, RXD1) will be 'typed' into the computer that the USB B port is connected to (a USB cable is required).

The USB host will see our circuit as a 'Human Interface Device' class-driver compliant keyboard (ie, just a normal keyboard). Therefore, it works on any operating system that supports generic USB keyboards.

Note that if you decide to use the Freetronics Leostick from Jaycar, then you may need to to update the bootloader to version 2 first. Jaycar still seems to carry the old version 1 bootloader which does not include the necessary components for USB HID compliance.

Simple instructions for applying the upgrade are on the Freetronics website.

Pete Mundy,
Nelson, NZ. ($60)

Revised firmware for the USB MIDI-Mate project

The MIDI-Mate provides a 2-way serial communications "bridge" between a USB port on a PC and external MIDI devices, so that the PC can send a MIDI music file out to a synthesiser and/or other electronic musical instruments. The PC can also receive MIDI messages from a keyboard or other MIDI controller, via the interface's MIDI IN jack.

The USB MIDI-Mate project presented in the October 2011 issue of SILICON CHIP worked reasonably well transferring simple 3-byte channel voice messages (like 'Note On' and 'Note Off') in both directions – that is, from the PC's USB port out to an external MIDI synthesiser and also from a MIDI keyboard back to the PC's USB port. But a number of constructors reported that it had serious limitations regarding 'special' data transfers in both the MIDI-to-USB and USB-to-MIDI directions.

In the MIDI-to-USB direction, it couldn't handle indeterminate-length 'SysEx' messages (which can be up to hundreds of bytes long, sent as a virtually contiguous stream) and nor could it handle 2-byte 'running status' channel voice messages. The latter is where a MIDI device sends a series of say 'Note On' messages with only the first in the series having its initial MIDI status 'header' byte, while the following messages have only the two data bytes. The receiving device is expected to 'remember' the status byte of the first 3-byte message and apply it automatically to the following 2-byte messages.

This 'running status' byte only changes when a new 3-byte message signals the arrival of a different type of message. The idea is to allow faster transfer of similar messages over a MIDI link.

Both of these types of 'special' MIDI message require somewhat more complex processing compared with the usual 3-byte channel voice messages like Note On, Note Off, Control Change and Pitch Wheel Change. This is especially true when it comes to transfers in the MIDI-to-USB direction, where all MIDI messages have to be processed to fit into 4-byte USB 'event packets', with a special USB packet identifier byte (containing a cable number and a code index number) prefixed to the 3-byte MIDI message.

So to handle all of these kinds of 'special' MIDI-to-USB message correctly, the project's firmware program had to be extensively revised.

Further testing also showed that the original firmware had problems when long 'SysEx dump' strings were to be transferred in the USB-to-MIDI direction. This turned out to be due to a 'bottleneck' caused by the speed differential between the USB bus and the much slower MIDI bus.

It turned out that the code to 'take delivery' of the stream of USB event packets arriving from the PC was being held up by the code sending them out to the MIDI out port, which could only send them out at the standard MIDI bit rate of 31.25kHz and one-byte-at-a-time. So some of the USB event packets ended up being lost.

After considerable time spent testing, revising and adding to the firmware for the PIC microcontroller (a PIC18F14K50) used in the project, we came up with a version which did handle both long indeterminate-length SysEx messages and truncated running status channel voice messages correctly, in the MIDI-to-USB direction. That left the USB-to-MIDI speed bottleneck problem, which involved almost as much work again.

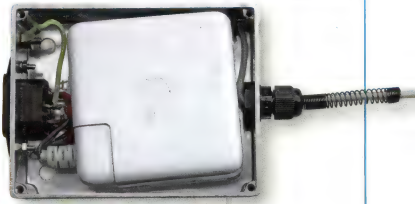
The solution turned out to be splitting the code handling USB-to-MIDI transfers into two parts – one part to 'take delivery' of the USB event packets arriving from the PC and the other part to send the MIDI data in those packets out to the MIDI output port. The two parts had to be separated by the software equivalent of a '2-port RAM buffer', where the data in the incoming USB packets is stored by the USB receiving code, while the MIDI output code is able to 'read them out' again at its own (slower) rate.

The finite amount of data RAM in the PIC18F14K50 device meant that we could only provide 150 bytes for this 'speed change buffer' but this should be enough to cope with quite long SysEx 'dump' streams – because it behaves as a 'circular' buffer where data is being written in and read out at virtually the same time. As a result, there's only a problem when the 'reading out' function ends up lagging behind the 'writing in' function by a full 150 bytes. This should only happen with *very* long SysEx dumps.

Finally, we have produced a revised-revised version of the project's firmware, to handle pretty well all of the MIDI-to-USB and USB-to-MIDI transfers correctly. The new 2311011C.hex file which can be used to reprogram the PIC18F1450 device in an existing USB MIDIMate will be available for downloading from the SILICON CHIP website, along with a zip file containing the source code files for the revised firmware.

Finally, note that the PCB and PIC18F1450 microcontrollers programmed with the revised firmware are available from the SILICON CHIP Online Shop.

Jim Rowe,
SILICON CHIP.



A new home for an Apple MacBook power adaptor

Apple MacBook power adaptors can have a problem whereby the low-voltage lead frays at the strain relief outlet. This can cause a complete breakage of one or both wires or overheating of the wires due to the few remaining wire strands taking all the current.

The power adaptor case must be opened up in order to cut and reconnect the faulty wire(s). As can be imagined, there are plenty of websites outlining the problem and showing how to open the case. A couple of examples are:

- http://warrantyvoidifremoved.blogspot.ie/2013/04/repairing-charredburnedbroken-cable-on.html
- http://www.instructables.com/id/MacBook-Mag-Safe-Charger-Budget-Repair-Disas/

Unfortunately, the case doesn't always open cleanly and even if it does, there's always the problem of how to reseal the case once the wire is repaired. Super glue is the method usually suggested but at least one website shows the case wrapped in insulation tape as a finished repair! Unfortunately, neither of these methods can be fully relied on to keep the case closed and if it does come apart, the user may be exposed to dangerous mains voltages.

A much better way is to fit the power adaptor inside a Jaycar HB-5067 diecast box measuring 119 x 94 x 34mm. It's a neat fit, while leaving sufficient room for an IEC male chassis connector (Jaycar PP4005) for the mains connection and a cable gland at the opposite end for the low-voltage outlet. A strain relief cable gland (such as the Altronics H4404) can be used to reduce the chances of the lead fraying again.

The case requires a cut-out for the IEC connector and a hole for the cable gland. A separate mains earth screw is also required to secure an eyelet for earthing the case to the mains earth at the earth pin of the IEC connector. It's necessary to use shakeproof washers under the nuts for the earthing screw and the screws used to secure the IEC connector.

It's also a good idea to fit a second locking nut to the earthing screw so that it cannot possibly come loose.

The mains wire cable from the power adaptor is cut and the wires stripped for soldering to the Active, Neutral and Earth pins on the IEC connector. Make sure that the brown mains wire is connected to the Active pin of the IEC connector and the blue wire to the Neutral pin. The green/yellow wire is for the Earth connection.

Slip heatshrink sleeving over the Active and Neutral wires before soldering them to the IEC connector. Then, when they are attached, slide the heatshrink up over the terminals and shrink it down to insulate the connections.

Finally, note that MacBook power adaptors do not produce any significant output until they are actually connected to the computer. Once that's done, communication between the computer and adaptor will then allow the adaptor to provide power for charging. The pinout for the MacBook MagSafe connector is available at http://en.wikipedia.org/wiki/MagSafe

John Clarke,
Silicon Chip.

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X-Y test pattern generator for analog scopes

Most good-quality CRT based oscilloscopes, such as those made by Tektronix, have adjustments for the geometry of the CRT display. This adjustment usually interacts with the trace rotation control.

It is easy to align the horizontal trace to be parallel with the CRT's graticule but the vertical or Y axis is harder to adjust while seeing its interaction with the overall scan geometry everywhere on the screen display in all four quadrants. Ideally a "box shaped" scan is required for the best adjustment possible.

This XY scan generator is based on a PIC12F509 microcontroller which was programmed using Microchip's MPLAB IDE v8.83. The program uses the bit clear and bit set instructions to set the outputs of the GPIO port high and low in a sequence, with appropriate delays called in from a simple delay subroutine with a parameter passed in the 'W' register. The *nop* instruction was placed between adjacent *bcf* and *bsf* instructions to prevent any possible read-modify-write problems.

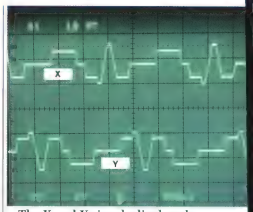
Each of the digital outputs, GP0, GP1, GP2 & GP4 of the GPIO register, were assigned to a quadrant to deflect the CRT beam into. The outputs are all positive logic levels. Negative deflection is required for the -x and -y deflections of the CRT beam. Therefore, the outputs are passed via two unity gain differential amplifiers (an OP295) running on a split power source to create the negative and positive-going signals required to deflect the CRT beam into its four quadrants.

The switching signals march the beam around the screen in a clockwise direction. The time to complete a full scan is close to 2ms (500Hz rate) so there is no visible scan flicker.

At the time in the scan where the Y deflection is zero (or X zero), GP5 is used as a gain control signal which acts on the four BS270 Mosfets to elevate the signal output and produce the over-scan. This generates the appearance of the two lines on the X and Y axis crossing each other in the centre of the square.

The signals generated by the PIC-12F509 have very fast leading and trailing edges. This means that they do not produce an easily visible line on a CRT face (in XY mode) and could only generate dots which would be seen in the pauses where the CRT beam was deflected into each quadrant during the time that the digital output was in a stable state.

Fortunately, feeding the signals to the abovementioned OP295 drives the op amps into slew rate limited mode with a very low slew rate of only 0.03V/us, making them into linear ramp generators. This makes the CRT beam visible. The OP295's outputs are not suitable for driving cables and current sinking/sourcing from its outputs affects the slew rate, so the outputs are buffered with a TLC272 dual op amp.



The X and Y signals displayed on a scope. The slew rate shapes the resulting waveforms into a pseudo analog format.

The scope screen photo shows the X and Y signals displayed on a scope. It can be seen how the slew rate shapes the resulting waveform into a pseudo analog format. The measured scan period is 2.105ms or a scan rate of 475Hz.

The unit's total current consumption is 8.7mA and about 12.7mA when terminated into a 50Ω load. Around 4.6mA of that is due to LED1. The output waveform produces a normal XY scan until the battery voltage drops to about 6.9V.

The software is *12509TMPO.asm* and can be downloaded from the SILICON CHIP website.

Hugo Holden,
Maroochydore, Qld.

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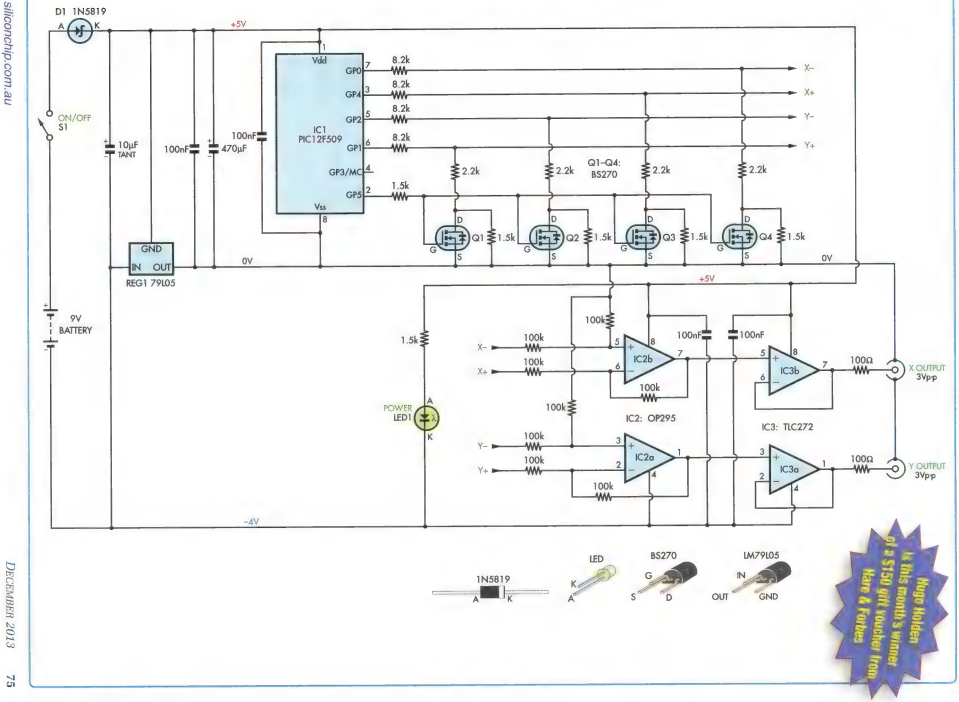

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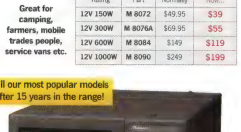

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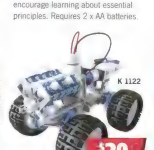

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Building the "TINY TIM" Stereo Amplifier

Part 2 – By Leo Simpson & Nicholas Vinen

Having introduced this compact stereo hifi amplifier in our October issue, let's start building it. Here we describe how to assemble the amplifier board and power supply and also how to prepare the case.

As explained earlier, this amplifier is a beef-up version of the Hifi Stereo Headphone Amplifier and is suitable for driving a wide range of speakers – especially the "Tiny Tim" speakers featured in our October issue.

Note that to complete the amplifier, some additional parts will be required beyond those specified in Part 1 – see the parts list in this article.

Start by assembling the main amplifier/preamplifer PCB. It's coded 01309111 and measures 198 x 98mm. First, though, there is a little surgery required on the PCB tracks which will allow it to operate with higher power.

On the PCB overlay there are eight links shown. However, the PCBs purchased from the SILICON CHIP online shop – www.siliconchip.com.au/shop – (and, presumably, any supplied in kits) will be double-sided so these links will already be in place, courtesy of PCB tracks.

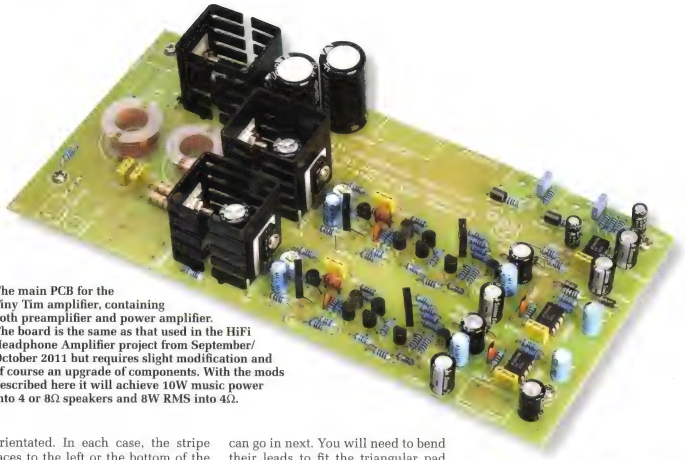
However, these boards may also have top-side tracks connecting the points labelled "A" to "D" (near the heatsinks at lower left). If so, you will need to cut these (use a sharp knife to cut sections out of the tracks and then check, with a multimeter, that there is no continuity between the points).

If you have made your own board or yours is supplied as a single-sided type, you will obviously need to install the links. Use 0.7mm diameter tinned copper wire.

And regardless of whether yours is a single or double-sided board, you will need to cut the two tracks on the underside shown of the board, marked with red "x"s on the PCB overlay diagram. As before, use a sharp knife then check that there is no continuity between A&B and C&D with your multimeter.

Now you can start fitting the components, starting with resistors, noting that two (both 680Ω) have ferrite beads slipped over their leads before they are soldered in place. Check each resistor against the colour-code table and also with a DMM set to Ohms to ensure you have the right value. Note that you may want to leave the resistor pads labelled A and B unsoldered at this point, with the resistor leads left long; this will make it easier to join wires to them later.

With the resistors in place, follow with the 14 1N4004 diodes, taking care to ensure they are all correctly



The main PCB for the Tiny Tim amplifier, containing both preamplifier and power amplifier. The board is the same as that used in the HiFi Headphone Amplifier project from September/ October 2011 but requires slight modification and of course an upgrade of components. With the mods described here it will achieve 10W music power into 4 or 8Ω speakers and 8W RMS into 4Ω.

orientated. In each case, the stripe faces to the left or the bottom of the board. The four BAT42/BAT85 small-signal Schottky diodes (D15-D18) near IC1 (upper-left) can then go in. Their orientations vary so take care.

If you are using sockets for IC1-IC3, solder them in now with the notches to the right as shown. Alternatively, you can solder the ICs direct to the board with the same orientation.

The MKT and ceramic capacitors are next on the list, followed by the 16 small-signal transistors. There are three different types so be sure to install the correct type at each location. Use a small pair of needle-nose pliers to crank the transistors leads so that they mate with the board holes and check that each transistor is correctly orientated.

The two 500Ω trimpots can now go in. That done, fit PCB pins at test points TP1-TP4 plus another two to support the tinplate shield between inductors L3 & L4. Then, mount the electrolytic capacitors but leave the two 4700μF filter capacitors out for the time being. Note that four of the capacitors are labelled as 50V types (a higher rating such as 63V is fine). As with the resistors, the capacitor leads labelled C and D are best left unsoldered until later.

The four BD139/140 transistors which are not mounted on heatsinks can go in next. You will need to bend their leads to fit the triangular pad pattern originally intended for a TO-92 transistor, as shown on the overlay diagram and photos. The metal mounting faces of each pair face towards each other.

Note that some BD139/140 transistors may lack a metal face; in this case you will need to look at which side has the transistor type number printed on it (which is opposite the mounting face) and ensure that these sides face away from either other.

Winding the inductors

The two air-core inductors (L3 & L4) are wound on small plastic bobbins. It is much easier to wind them if you make a winding jig, as shown in the panel on P84.

To wind the first coil, first secure the bobbin to the jig with one of its slots aligned with the hole in the end cheek. That done, feed about 20mm of a 1m-length of 0.8mm-diameter enamelled copper wire through the hole, then carefully wind on 20.5 turns before bending the end down so that it passes through the opposite slot in the bobbin. Trim the "finish" end of the wire to 20mm (to match the start end), then secure the winding with a layer of insulation tape and remove the bobbin from the winding jig.

A 10mm-length of 25mm-diameter heatshrink tubing is used to finally secure the winding. Slip it over the outside and gently heat it to shrink it down (ie, be careful to not melt the bobbin).

The second coil is wound in exactly the same manner. Once it's finished, scrape the enamel off the leads on both inductors and tin them before fitting them to the PCB.

Further modifications

The tracks cut earlier allow us to reconfigure the power supply so that the output stages run off the unregulated ±20V rails but to do that, we also need to run four insulated wires on the underside. It is simply a matter of connecting the pads labelled A-A, B-B, C-C and D-D.

To join A-A and B-B you can use light duty wire as these only need to be able to carry enough current to power the preamplifier; even Kynar (wire wrapping wire) or bell wire is suitable. The two shorter runs, C-C and D-D, can carry in excess of 1A so medium- or heavy-duty hook-up wire is more suitable.

Completing the PCB assembly

The tinplate shield between the two inductors can now be installed. This shield measures 35 x 15mm and can

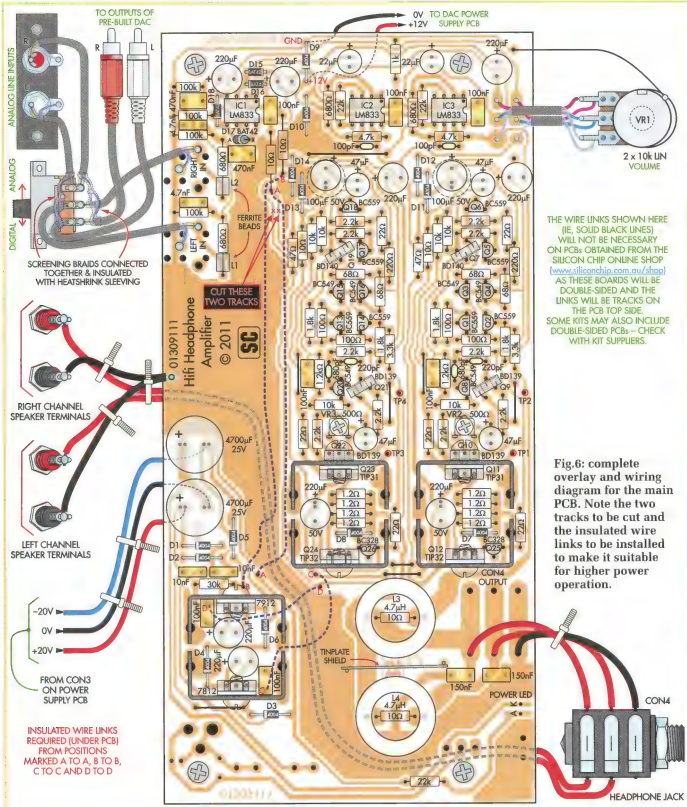


Fig.6: complete overlay and wiring diagram for the main PCB. Note the two tracks to be cut and the insulated wire links to be installed to make it suitable for higher power operation.

be cut from the lid of a large tin (or similar) using tin snips. File the edges smooth after cutting, then temporarily position it between the two PC pins and mark their locations.

That done, hold the shield in an alligator clip stand and melt some solder onto either side at the marked locations. It may take 10 seconds or more to heat it enough for the solder to adhere.

Finally, flow some solder onto the tops of the two PC pins before fitting the shield in position and remelting the solder to secure it.

Mounting the heatsinks

The two regulators and six power transistors are mounted on six large flag heatsinks. These have two posts which pass down through the PCB for

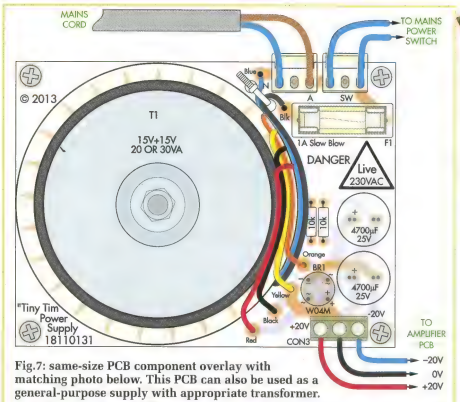
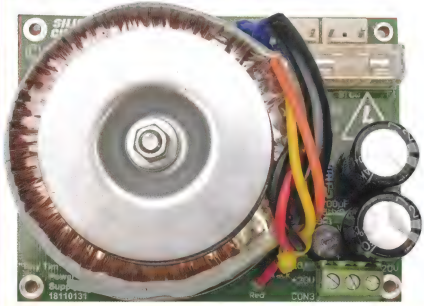


Fig.7: same-size PCB component overlay with matching photo below. This PCB can also be used as a general-purpose supply with appropriate transformer.



Here's the underside of the power supply board, completely covered with a sheet of fibre insulation.

support. Two of the heatsinks have two transistors mounted on them, one each side (see overlay and photos).

Start by loosely fitting the 7812 and 7912 regulators to their heatsinks. Note that, in each case, the regulator's metal tab must be isolated from its heatsink using an insulating bush and silicone washer.

That done, fit the 7812 regulator assembly through the lower set of holes just above CON3 and D3. If the heatsink has "solderable" pins, flip the board over and solder one, then double-check that it is sitting perfectly flush with the board before soldering the other. Since you have to heat up quite a bit of metal, it could take 15 seconds or more before the solder adheres to the post.

Alternatively, if the heatsink doesn't have "solderable" pins, use pliers to bend the tabs outwards far enough so that it is secured to the board.

Having secured the heatsink, check that the insulating washer is properly aligned with the regulator and tighten the mounting screw. The regulator's leads can then be soldered. Repeat this procedure for the 7912 regulator.

The two TIP32 power transistors (Q12 & Q24) are mounted in identical fashion to the regulators. By contrast, the heatsinks for the two TIP31 power transistors (Q11 & Q23) have the BD139 V_{BE} multiplier transistors mounted on the other side. Be sure to insulate all the transistors from the heatsinks using silicone washers and insulating bushes as necessary.

The power connector, power switch and LED, input and output sockets and volume control potentiometer are not fitted to the board; instead, most of them are chassis-mounted and connected with flying leads We'll get to that later. First, let's assemble the power supply.

Power supply

Before fitting any components, use the power supply PCB as a template to cut a sheet of fibre insulation (often sold as Presspahn or elephantide) to 100 x 75mm and drill through the four mounting holes to make corresponding holes in the Presspahn sheet. Also make a hole corresponding with the transformer mounting hole and enlarge this to 5.5mm diameter.

Now begin assembly, follow the overlay diagram of Fig.7. Fit the two resistors, then the bridge rectifier – make sure its + symbol lines up with that shown on the PCB overlay. Follow with the terminal block (wire entry holes towards board edge) and then the fuse holder.

We need to install the two pin headers next but there's a bit of a trick here. In the October issue, we showed the power switch connected between the Neutral pin of the mains power plug and the transformer primary/fuse. While this will work, it means that the transformer and fuse are live even when the power switch is off.

Fig.8: finally, the only other PCB which requires assembly, the "MiniReg" universal power supply (used here to power the DAC) which we published in the December 2011 issue.

Of course, when opening up the unit for any reason (eg, to replace the fuse) it is always a good idea to ensure that it is unplugged but in case somebody fails to do this, it is safer to have the switch between the mains plug Active pin and the rest of the circuit. Note that it's possible for mains Active and Neutral to be swapped in house wiring so this doesn't guarantee safety (hence the advice to always unplug a device before servicing it) but this is a safer arrangement most of the time, ie, when the house wiring is correct.

Now since we're recycling the mains cord from a set-top box (or whatever other device you decide to rat), we don't know how it's wired. We checked two set-top boxes – both from the same manufacturer – and found that the mains cords were wired opposite to each other. So you will need to set your DMM on continuity mode and work out which pin of the header plug is wired to Active (normally indicated with an "A" or "L" moulded into the plastic mains plug housing).

Once you've determined that, you can install the two pins headers with an orientation such that the Active wire will go to the terminal marked "A" on the board (ie, the one directly adjacent to the switch header). This is easier than trying to swap the pins to the polarised plug.

With the two headers in place, connect the mains cord to the left-hand header (leave the other end unplugged!) then double-check that the Active pin on the plug is electrically connected to the left-hand pin of the switch header. If not, you will have to remove the left-most header and re-install it the other way around. Once you have verified that, fit the two electrolytic capacitors.

Now before mounting the transformer, feed a cable tie through one of the two large holes at upper-right and then back up through the other, so that it passes under the board in the space between them. Make sure it's the right way around to do the tie up later, then place the sheet of Presspahn you prepared earlier under the board and feed the transformer mounting bolt up through this and the hole on the PCB.

Check that the corner screw-holes more or less line up and then slide the transformer's rubber pad over the bolt, place the transformer on top (with wires exiting on the top side) and use the rest of the mounting hardware supplied with the transformer to loosely hold it in place. Typically this consists of another rubber pad, a metal dish, a spring washer, a flat washer and a nut.

Rotate the transformer so that the wires line up with the wire pads on the right-hand side and then tighten the nut (but not too tight!). How you proceed depends on which transformer you are using.

Jaycar MT2086:

The primary and secondary leads will need to cross over to reach the appropriate pads. Luckily, the primary leads are double-sheathed and so pro-

A Winding Jig For The Inductors

The winding jig consists of an M5 x 70mm bolt, two M5 nuts, an M5 flat washer, a piece of scrap PC board material (40 x 50mm approx.) and a scrap piece of timber (140 x 45 x 20mm approx.) for the handle.

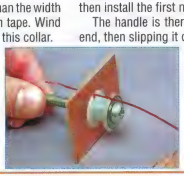
The flat washer goes against the head of the bolt, after which a collar is fitted over the bolt to take the bobbin.

This collar should have a width that's slightly less than the width of the bobbin and can be wound on using insulation tape. Wind on sufficient tape so that the bobbin fits snugly over this collar.

Next, drill a 5mm hole through the centre of the scrap PC board material, followed by a 1.5mm exit hole about 8mm away that will align with one of the slots in the bobbin.

The bobbin is then slipped over the collar, after which the PC board "end cheek" is slipped over the bolt. Align the bobbin so that one of its slots lines up with the exit hole in the end cheek, then install the first nut.

The handle is then fitted by drilling a 5mm hole through one end, then slipping it over the bolt and installing the second nut.



The power supply PCB is in the left rear corner, with a protective shield alongside. The DAC is in the opposite corner with its "MiniReg" power supply in front. Pretty much the whole of the rest of the case is taken up by the main PCB.

vide sufficient insulation to remain safe in this configuration.

Trim both the primary and secondary leads to length so that they reach their respective pads, leaving a little bit of slack and allowing for the fact that we are going to tie the primary leads down to the PCB before soldering them to the two pads. You can check this by pushing them down onto the PCB with a finger, between the two tie holes, then arching them over to reach the solder pads.

The secondary wires are colour-coded and go to the appropriate labelled pads at the lower-right of the PCB. You will probably need to trim these to slightly different lengths so they will all reach their respective pads.

Altronics M4915A:

This has the opposite wiring arrangement to the Jaycar transformer so the primary and secondary leads to not need to cross over. Note that the colour coding is different though; the white lead goes to the pad labelled "yellow" while the others match up with their respective colours. As with the Jaycar transformer, you will need to allow a bit of extra length for the primary (blue and brown) leads to be tied to the board before being soldered to the pads labelled "Blue" and "Bl." (it doesn't matter which goes to which).

Finishing the power supply

With the transformer leads trimmed and stripped, run the two primary leads through the cable tie you inserted earlier and do it up tight, then trim off the excess length. Solder all six leads to the appropriate pads, as explained above. Use two or three more cable ties to lace the secondary leads together well so that should one break loose, it won't go floating around (and also to contain the magnetic field as much as possible).

You can now fit the four tapped spacers with the PCB and fibre insulation panel sandwiched inbetween. Use a Nylon M3 screw in the upper-right corner, near the mains tracks, to ensure that a metal screw in the other end of the Nylon spacer can't possibly make a connection through to the top of the board, where a stray wire could make the chassis live.

Insert a 1A slow-blow fuse into the holder and clip the top cover on. We'll test the power supply board later once it's in the case.

DAC power supply

We're using the MiniReg, described in the December 2011 issue of Silicon Chip, to power the DAC, which runs off 6V DC at about 50mA. The MiniReg is fed from the 12V rail from the amplifier via the 2-pin plug soldered earlier. Follow the instructions in the December 2011 issue (or instructions accompanying the MiniReg kit) to assemble it. Don't worry about adjusting the output voltage, we can do that later.

You will need to make up a short (~50mm) 2-wire cable with a polarised header plug on one end and a 2.5mm inner diameter DC jack plug at the other end, to suit the DAC. This should be wired so that the inner conductor of the DC plug is positive. Refer to the MiniReg instructions to see which pin is the positive output and which is the negative. You will also need to short out the switch terminal (eg, with a jumper shunt).

The amplifier power indicator LED can also be run from the MiniReg and again this will require a 2-core cable with a polarised header plug at one

end. Make this one a bit longer – say 100mm. Cut the LED leads short and solder the other end of the wires to these, with the cathode (flat side of LED lens) going to the terminal marked "K" on the MiniReg PCB. Put these cable assemblies aside, for now.

Wiring

Cables for power, signal input and output leads must be soldered to the amplifier board along with shielded cable to connect to the volume pot. While you could solder these wires directly to the board, doing so with everything already in the case is awkward. Hence, we fitted PC pins to most of these pads and soldered the wires to these later.

There are a total of 17 required – two for each input, three for the outputs, six for the potentiometer connections, three for the power supply wires and one for the speaker ground returns. However, upon reflection, we recommend soldering the power supply wires directly to the underside of the board, leaving 13 PC pins to fit.

Solder the pins in now, to the pads shown on the overlay diagram. Note that most of these holes are much larger than required for PC pins and some will let the whole pin pass through. So you will need some sort of a clamp (eg, self-closing tweezers) to hold the pins in while you solder them.

For the power supply, solder 100mm lengths of heavy-duty wire to the 4700µF capacitor terminals. We have left fitting these capacitors until now so that you can wind the wire around the leads before soldering. Colour code the wires as shown.

Two more black heavy-duty wires then need to be soldered to the large ground plane area above these capacitors, for the speaker outputs. If you have a commercially-made board, you will need to scrape away some of the solder mask to allow this. If you like, you can drill a hole through the board and feed the wires in from the top and you can even fit a PC pin or two so the wires can be later soldered to the top of the board, if you want to.

You will also need to connect wires to run the DAC from the regulated +12V rail on the amplifier board. Take light duty figure-8 cable about 50mm long (or two strands from a ribbon cable) and crimp/solder them into a 2-way polarised header plug. The other ends go to the pads shown in Fig.7, with 12V to pin 1 of the plug. A pin 1 indicator is normally moulded into the plastic plug housing.

Parts List (in addition to parts listed in Part 1)

17 PCB pins
2 chassis-mount RCA sockets, one red & one white (or black)
1 panel-mount DPDT miniature slide switch (Jaycar SS0821, Altronics S2010)
1 sheet fibre insulation (eg Presspahn or elephantide), at least 100 x 115mm
1 100mm length 8mm diameter black heatshrink tubing
1 200mm length 5mm diameter black heatshrink tubing
4 M3 Nylon tapped spacers & various M3 Nylon nuts (to suit DAC installation)
6 M3 x 10mm Nylon machine screws
2 M3 x 6mm Nylon machine screws
4 M3 x 5mm machine screws
3 M3 Nylon nuts
2 M2 x 10mm machine screws and nuts
1 jumper shunt
3 2-pin polarised header plugs with crimp pins
20 small cable ties
3 small adhesive wire saddles/clamps
1 100mm length 8mm diameter red heatshrink tubing
1 panel, 2mm plastic or 1mm aluminium, large enough to cover rear panel of case
1 5mm LED bezel clip (optional)

Chassis preparation

A number of holes must now be drilled in the front, rear and base of the case, to attach the various connectors and mount all the modules. Start with the rear panel which needs holes or cut-outs for the four speaker terminals, analog RCA input sockets, analog/digital selector switch and DAC inputs.

If you are using a case which originally housed a commercial piece of equipment (in our case, a set-top box), there will be many holes in the rear panel, most of which are not in the right location to re-use. The simplest way to solve this is to attach a new rear panel on top of the existing one, covering these up, which you can then drill and cut new holes in.

This panel can be metal or plastic, providing it is strong enough. We used a 2mm thick plastic front panel from an instrument case that we had spare. Don't use thinner plastic as it isn't strong enough. A sheet of aluminium or tinplate is also suitable.

Cut the panel to the same size as the rear panel of your case, or at least large enough to cover up all the holes except that for the mains cable. Place this over the rear of the case and drill at least two 3mm holes through both. We put one at the end near the mains cable and another in the middle.

Feed through short machine screws and tighten these onto nuts to hold the panel in place. If one of the holes is near where the mains power supply will go, use a Nylon screw and nut there.

You can now mark out the positions for the four binding posts which should go near the middle of the rear panel, but not too close to the power supply mounting location – leave at least 10mm separation. We spaced them apart by about 20mm with 5mm extra between the two pairs; if you put them much closer together than this, this makes connecting wires awkward.

Now mark positions for the TOSLINK and RCA socket inputs of the DAC board in the right-hand rear corner, as well as a rectangular cut-out for its selector switch to fit through. Since this switch body sticks out further than the TOSLINK connector, a slot will need to be cut to fit the whole thing through.

We elected to place the stereo RCA analog input sockets and analog/digital selector slide switch underneath the DAC inputs as there wasn't enough room in our case to place them side-by-side. You may want to do the same. In this case, make sure the holes for the DAC inputs and switch are towards the top of the case.

With the positions for all these connectors marked out, start by drilling pilot holes right through both the original rear panel and the new panel on top. Enlarge the holes for the binding posts and RCA sockets until the connectors fit through. Ideally, the

binding posts and RCA connectors should be a snug fit.

The TOSLINK input, DAC selector switch and analog/digital selector switch require rectangular cut-outs and these are too small to easily nibble so you will probably have to drill a row of holes in each case and then slowly file it into a rectangle using needle files. You may find it easier to temporarily remove the new rear panel and file holes in the two panels separately before re-fitting it. Note that it's more important that the holes are neat in the outer panel than the inner one.

Test-fit the DAC board and make sure that it can be butted right up against the rear panel. For the analog/digital selector slide switch you will need to file a slot for its actuator as well as two small mounting holes for screws. Once you have it in place and do the screws up, check that the slot is large enough for it to smoothly slide to the end stops in both directions.

Make sure to de-burr all the holes on both sides before fitting the connectors.

Front panel

You will also need to drill some holes in the front panel, or if possible, enlarge existing holes. Make sure you don't compromise the insulation for the existing mains switch when doing so as you will want to re-use it.

As you can see from the photos, we drilled a hole at the left end for a 6.35mm headphone socket and enlarged existing holes at right, near the power switch, for the 16mm volume control pot and 5mm power LED. You may also have to cut away some of the internal structure of the front panel in order to get these to fit. We used a plastic bezel to make the power LED a snug fit in the hole, then glued it in place using hot melt glue; you could also use silicone sealant.

If there are any remaining holes in the front panel near the mains switch, file a piece of plastic to the shape of each hole and glue it in place. We used black plastic, to match the existing front panel, and glued them with cyanoacrylate ("super glue"). As you can see, the resulting seams are quite subtle.

Module mounting holes

The next step is to drill a series of 3mm holes in the bottom of the case for mounting the various modules. First place the amplifier board near the front-left corner and mark out its four corner hole positions in the base. Then drop the power supply PCB in at left rear, close to but not right up against the rear panel, and mark out its four mounting hole positions.

Mark out two more holes, just to the right of the power supply board, one roughly in line with the rear mounting holes and the other about 50mm closer to the front of the case. These will be used to hold a small Presspahn shield in place, for extra safety.

With the DAC in position, mark the locations directly below its four mounting holes (eg, using a sharp drill bit) although note that you may not be able to fit pillars to suit all four if you are putting the RCA sockets and switch underneath it; also consider where the wiring for these will go. Two or three mounting holes are sufficient.

Finally, choose a location for the MiniReg near the amplifier and DAC boards and mark out positions for its mounting holes too.

You can then remove all the modules from the case, drill all the holes to 3mm and de-burr them. There should be about 17 mounting holes in total.

Testing the power supply

You can now temporarily install the power supply PCB in the case, with the mains connectors towards the rear and plug in the mains cord and switch. Make sure that the mains cord goes into the right socket, ie, that closest to the transformer. Ensure the fuse is in place and the cover clipped on.

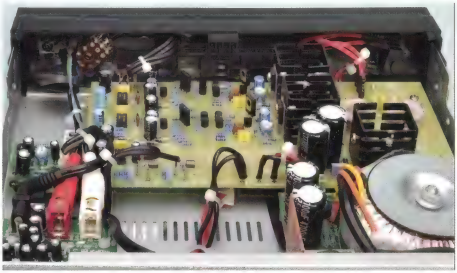
It's a good idea to connect a DMM (or two) to the low voltage outputs with short lengths of wire (that can't short together!) and clip leads so that you can check the output without having to hold probes in place. But you can use regular probes as long as you are careful not to go anywhere near the mains side of thing while the unit is plugged in.

Check that there is no continuity between either mains plug pin and the case and that there are no loose conductors near the power supply board and switch the unit's mains switch to on. Then stand back, plug in the mains cord and switch on the power point. Check the voltages at the output screw terminal of the power supply. You should get pretty close to 20V between the middle terminal and those on either side, with the positive output being to the left. Ours measured around +21.5V and -21.5V.

If that tests OK, switch off and unplug the unit. If you didn't get anything, there could be an open circuit connection somewhere on the board while if the fuse blows, that suggests there is a short circuit somewhere. In either case, you will have to remove the power supply board and inspect it carefully.

Wiring it up

With the modules built and all the holes in the case drilled or cut and de-burred, all that's left is to fit the modules and wire them up. We'll go through these remaining steps in Part 3 next month and also present some performance data for the complete amplifier. SC



Here's a view from the back to the front, showing how we made the bits fit into what was originally a set-top-box case. Once the lid goes on you'd never know!

Altronics A2696 DAB+ & Internet Tuner

Adding digital radio to your hifi set-up is a logical move, as it gives you better sound and more stations to listen to. But why be limited to broadcasters in your city? This digital tuner will access the Internet and bring you many thousands of radio stations from across the world, catering for all preferences.

IF YOU WOULD like to add digital radio to your hifi system, you will find the task surprisingly difficult. You might think that you could replace your amplifier with one that has an in-built digital tuner but nearly all amplifier/tuner combinations on the market only support analog (AM/FM) broadcasts. Even individual component tuners are hard to find these days and if you do find one, the chances are that it would be analog only.

This is where Altronics comes to the rescue with the Opus One A2696 which is a component DAB+ and FM tuner styled to fit within a component hifi set-up. It's not your normal radio receiver though – it takes the concept of a digital radio to a whole new level.

That's because in addition to receiving DAB+ and FM stations, this tuner can also connect to the internet and find radio stations there. This means that you can listen to a radio station in another country as if it was a local broadcaster. You are spoiled for choice here as the internet has thousands of stations with a mind-boggling range of programs and content.

But that's not all the Opus One A2696 can do – it can also locate and play podcasts hosted on the internet. For example, if you have missed this morning's ABC AM program, you can later look it up and listen to it using this tuner, just as if it was being broadcast live.

Other sources of audio that this remarkable appliance can play include music on a computer that is connected to your home network or audio files saved on a USB memory stick.

DAB+ and FM

The DAB+ receiver works as expected. It covers the Australian DAB+ broadcast range (174.982-239.2MHz) and we found that it was easy to set up and find the local DAB+ stations.

The antenna input is a standard 75Ω PAL socket and in most cases, you can get away with connecting this to your TV antenna via a splitter. However, digital radio is vertically polarised in Australia so you will get a better signal with a dedicated antenna, especially in marginal signal areas.

During our tests using a TV antenna, we occasionally experienced DAB+ signal drop-outs, even though the

digital TV signal from the antenna was reasonably strong.

The FM section of the tuner uses the same antenna. The FM receiver is nothing special but it does support RDS which is a protocol for embedding small amounts of digital information in the FM signal. Examples include time, station identification and program information. If the FM broadcaster is using RDS, the data transmitted will be displayed on the tuner's LCD screen.

Internet radio

In order to access the internet-related functions, you obviously need to connect the unit to the internet. The A2696 provides for this by including both WiFi (via an antenna on the rear panel) and a wired 10/100 Ethernet socket. WiFi support includes both 802.11b & 802.11g, along with a comprehensive range of security protocols (WEP, TKIP, WPA, WPA2 & WPS).

Set-up is reasonably easy and we had it linked to our router in just a few minutes. Once you are online, you will find that tuning into an internet radio station is ridiculously easy. No special knowledge is required and even the most technically challenged would be able to quickly find something to listen to.

Finding a station

The tuner has access to an estimated 20,000 radio stations (we did not try to count them), so the range is truly huge compared to the dozen or so that you might receive via DAB+. Such a large selection needs some way of narrowing the choice so that you can zero in on what you like and the A2696 does an excellent job in this regard.

First of all, you can narrow the search by selecting the genre that you are interested in and/or the country where the station is located. Other options include selecting from new stations, most popular stations or your favourite stations.

If, for example, you choose the genre option, the tuner will then present you with a suitable list (Blues, Celtic, Classic Rock etc). After choosing from this list, you then have a sub-choice of country, most popular, etc. Finally, you will reach a list of stations displayed by name. From there, it's just a matter of pressing the button to select one and if you like it, you can add it to your favourites.

Of course, you also have other ways of finding a station. You can start by region (Africa, Asia, Europe etc), then select by country, then genre. Another option is to search by name (or a fragment of a name) or you can search stations that you recently listened to etc.

Navigating through all of these options and menus is easily done using a large front-panel jog-wheel which is pushed in to select an entry.

Two other front panel controls, the MENU and BACK buttons, complete the menu navigation facilities. Despite a few peculiarities that can sometimes trip you up, the menu system is generally logical and intuitive.

Bandwidth requirements

In order to stream audio over the internet, you need to have a download bandwidth of at least 256kb/s and preferably 512bb/s. For readers who have an unlimited download plan, listening to internet radio will be essentially free. However, if you are on a limited plan, you need to consider how much

Fig.1: this is the standard station read-out shown on the LCD when you are listening to DAB+ radio.

Fig.2: when you want to find an Internet radio station you can search by location, by genre, or by name. Alternatively you can look up lists of popular or new stations.

Fig.3: if you decide to search the Internet by genre this is the sort of list that you will be presented with. The list is compiled by Frontier Silicon who send it to your tuner.

Fig.4: if you search for an Internet radio station by country you first have to select the region and this is the typical selection.

Inside the A2696 – the Venice 6.2 module is the shiny metal box on the left and is mounted on a PCB along with some support circuitry. The large PCB on the right is the power supply while another PCB at the front holds the front panel display and controls. The Venice module does all the work and everything else is just there to support the module.

of your download allocation will be consumed in this way.

Typically, internet stations stream music in the MP3 format at 32-192kb/s. Most high-quality stations use 128kb/s and at that data rate, you will end up downloading about one megabyte a minute.

You can use this rule of thumb to work out your own usage but as an example, if you listened to internet radio for four hours per day, every day of the week, you would download about seven gigabytes (7GB) per month.

Fig.5: a typical display while listening to a station in sunny Port Douglas – and we are on the opposite side of the country.

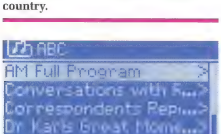


Fig.6: we searched for podcasts broadcast by the ABC and this was the result.

In our tests, the tuner coped well with internet congestion and interruptions. If it did lose the connection, it would quietly retry until it reconnected and then resume playing the program. It was only when we saturated our internet link with a huge high-speed file download that any real problems began, with the tuner struggling with numerous and lengthy drop-outs.

Generally, the quality of the audio streamed over the internet is excellent and after a while you tend to forget where your music is coming from. We took a liking to 106.3 in Port Douglas (thousands of kilometres away) and it was strange hearing them refer to "sunny Port Douglas" while it was wet and windy in our location.

As previously stated, you can also listen to podcasts hosted on the internet. Once again, the choice is huge, with almost 10,000 podcasts available.

The procedure for selecting a podcast is similar to selecting radio stations (ie, by genre, country etc). Once you have found the desired podcast, you then go on to select the episode. The selected program will then be played just as if it was being broadcast live.

Network streaming

If you have music stored on a computer in your network, you can play that using the A2696 and DLNA. DLNA is a set of standards created by the Digital Living Network Alliance to enable the sharing of digital media between multimedia devices such as servers, players, TVs etc. Windows 7/8 supports DLNA out of the box but Macintosh users need to run some extra software to get going.

When you connect to a DLNA server, you will be presented with a set of choices such genre, artist, rating etc. These options depend on the DLNA server and the tags in your music files and help you when sorting through a large media collection.

The decoders in the tuner can play a wide range of formats including FLAC, WAV, AAC, MP3, WMA and RealAudio – so you have plenty of choice. The A2696 will even find and play playlists stored on your server.

As if that's not enough, you can also plug a USB memory stick into a socket on the front panel of the tuner and play your music from there. The USB playback facility supports the same range of audio formats as network streaming and navigation through the files is done using the folder structure on the USB stick.

Using the A2696

We were unable to perform any technical tests but the sound produced was clean and noise-free. There was an over-emphasis in the bass which may have been added by the broadcaster but this can be corrected using an equaliser built into the tuner. Disappointingly, this only works on the analog output, not the digital TOSLINK output.

When not navigating the menu system, the large jogwheel becomes the volume control – but again it is only effective on the analog output. It's a puzzle as to why a tuner needs a volume control in the first place and this control would be much better employed as a station selector.

For such a complex device, the A2696 is remarkably easy to drive. About the only complaint is that the small 2.5-inch LCD display is only legible when viewed straight on which can be a problem if your hifi gear is on

The rear panel carries a TOSLINK connector for digital audio, two RCA connectors for analog audio out, a wired Ethernet (LAN) socket and a WiFi (WLAN) antenna socket. There's also a 75Ω PAL socket for a DAB+/FM antenna. Note the 2-way labelling – very handy if you're looking down from above!

a low shelf. In that case, you will have to kneel down to follow the menus.

To get around this problem, you can use an application called "Libretto" which runs on your smartphone. This provides a comprehensive remote control and display for the tuner, complete with the menus.

The manual describes the application running on an iPhone or iPod touch but in our case, we tried the Android version as suggested on the Altronics website. Unfortunately, this version didn't work with the A2696.

The tuner lets you save favourite stations for each mode and by using this facility, you can quickly return to them. A remote control is supplied and one of its features is that it allows you to jump to a favourite station with a single button press.

Build quality

The A2696 has a solid feel with its black metal case and textured front panel. The LCD and power indicator are both blue, in keeping with modern styling (green is just so yesterday!).

On the back panel there is a wired Ethernet socket and the WiFi antenna. Also on the rear are two RCA connectors for analog audio out and an optical TOSLINK connector for digital audio. The collection is rounded out by a 75Ω PAL socket for the DAB+/FM antenna.

Like many electronic goods these days, this tuner is a generic product built in China. It's also available in other guises such as the Sansui WLD+201L in the UK, which is identical except for the remote control.

Inside the tuner

We couldn't resist opening the case and were surprised by what we found. Mostly it was open space but what was interesting was that all the hard work – the DAB+ tuner, Ethernet, WiFi, internet access, DLNA, USB etc – was performed by a small 40 x 110mm metal-clad module just a few millimetres thick.

This is the Venice 6.2 module manufactured by Frontier Silicon. As you can see from the photograph, it has a DAB+/FM antenna input at one end, a WiFi antenna input at the other end and a 60-pin connector for control and audio output along one edge. The remainder of the circuitry in the tuner is basically just the power supply and supporting circuitry for this module.

Frontier Silicon, by the way, is a privately-owned UK company that has built a large stake in the digital radio market. Their modules are used in most digital radios and SILICON CHIP used the Venice 7 module in the High-Quality DAB+/FM Tuner described in October-December 2010. The Venice 6.2 module, however, takes things to a much higher level with its internet access, including WiFi, the TCP/IP protocol stack and much more.

Frontier Silicon also provide a reference design for a complete DAB+/internet tuner based on the Venice 6.2 module and this tuner is essentially an implementation of that design. Purchasing this technology is probably expensive but it does mean that the manufacturer of the A2696 did not have to spend time designing complex digital circuitry and therefore could quickly enter the market.

Station catalog

Another area where Frontier Silicon has had a hand in the A2696 is the catalog of internet radio stations – necessary in order for users to make selections. We discovered the importance of a catalog when we attempted an internet radio project of our own some time ago. Eventually, we had to give up on the project because we couldn't find an easy way of locating and connecting to a station.

Most internet stations broadcast for free but the only way you can listen to them is by finding their website and clicking on a button to start streaming to your PC or smartphone, etc. Even then, the details of the protocol (port number, etc) are usually hidden.

There are companies (eg shoutcast.com) that index internet radio stations but they require a hefty fee for access. To address this issue, Frontier Silicon set up a separate organisation (www.wifiradio-frontier.com) whose job it is to build an internet station catalog.

The Venice 6.2 module contains the security codes to access this catalog via an internet connection. For example, when you select by genre, the list to be displayed will be sent to your tuner by Frontier Silicon. Similarly, when you select a station, the access details (IP address, port number etc) will also come from Frontier Silicon. This catalog is not stored in your tuner and is not available publicly – only authorised products can access it.

This raises an interesting question: what happens if Frontier Silicon stops funding their indexing service (not that we're suggesting that this is going to happen)? The answer is that you would completely lose the internet function in your tuner. There is no provision to manually enter a station's (or a podcast's) details into the tuner, nor is there the ability to use an alternative indexing service.

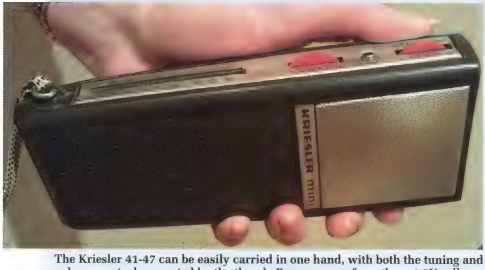
So if that ever happened, you would be limited to just DAB+ or FM stations.

Wrap up

The Opus One A2696 is well designed and deserves full marks for its comprehensive features and ease of use. It would be an excellent addition to most hifi set-ups. The list price of the tuner is normally $399 but Altronics currently has it on special until the end of December for $319. SC

Vintage Radio

By Ian Batty



The Kriesler 41-47 can be easily carried in one hand, with both the tuning and volume controls operated by the thumb. Power comes from three 1.5V cells.

Too Cool for School: Kriesler 41-47 "Mini" transistor radio

Manufactured in Australia during the mid-1960s, the Kriesler 41-47 is a pocket-size 6-transistor radio with some rather interesting features. It not only looks "cool" but was also a good performer, despite its relatively simple circuit design.

IMAGINE THIS: a kid in the mid-1960s takes his new "trannie" to school and is showing it off during class. One of the teachers confiscates it, handing it back at the end of the day with instructions to never bring it in again.

I can well imagine the kid not really understanding the reasons for this but concluding that this marvellous piece of technology was just "too cool" for his fuddy-duddy teacher to "get".

If looks are important, then the Kriesler 41-47 "Mini" pretty much beats the competition hands down (as did another Mini of the decade). Its sleek looks are just, well, "cool". It features a black case with two large silver speaker grilles, a large side dial, thumbwheel controls and a carry strap. The case is a single moulding with a plastic hinge joining the two "clamshells" and even rival engineers of the day reckoned that it was an outstanding piece of design.

And so they should have – the Kriesler Mini was designed by Harry Widmer, the design director at the Kriesler Radio Company of Sydney (the company was then owned by Philips). In 1966, he won the prestigious F. H. Edwards Laurel award for designing the set's polypropylene plastic case, the judges noting that this was the first such application of this material in a portable radio worldwide.

Of course, size was another important ingredient in the design of the 41-47. It's easily carried in one hand and can be operated using the thumb.

The 41-47: first look

The Kriesler 41-47's circuit is similar to the Bush TR82C described in the September issue, although the presentation and method of assembly is quite different. For example, unlike the TR82C, the 41-47 uses a printed circuit board (PCB) to accommodate most of the parts (the TR82C used point-to-point wiring and a metal chassis).

Despite its obvious advantages, PCB construction can restrict access to the circuit for servicing. That's because most sets mount the board "component side" up, leaving the copper tracks on the "inside" of the case. In addition, the transistors are often mounted close down on the PCB on short lead lengths, making it difficult to connect a test probe to make measurements or for signal injection.

Some early transistor set manufacturers mounted the resistors flat against the board, making it easy to measure voltages at each end. Others, to save space, stood them upright, with one end right down against the board. This meant that access could only be gained at one end without lifting or removing the PCB.

As a result, AC and RF measurements, and especially signal injection, can be more difficult. Regency's TR-1, for example, used neutralisation components in its IF section and these could be tapped onto fairly easily for signal injection. By contrast, sets such as the Kriesler 41-47 do not offer such connections, so any detailed analysis must be done with the PCB either completely removed or swung out from the case.

Circuit description

Like the TR82C, the 41-47 uses a

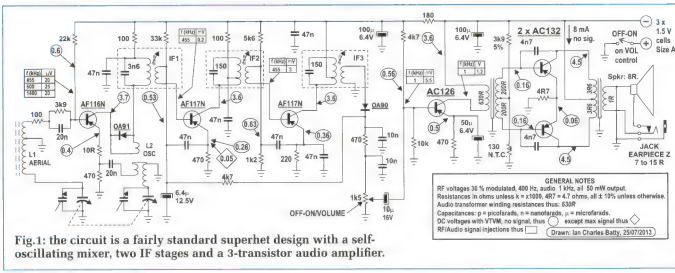


Fig.1: the circuit is a fairly standard superhet design with a self-oscillating mixer, two IF stages and a 3-transistor audio amplifier.

fairly standard circuit and as mentioned, the two are similar. Fig.1 shows the details. It employs a self-oscillating mixer, two IF stages, a diode detector (OA90) and an audio driver feeding a push-pull transformer-coupled output stage.

In all, the 41-47 uses a total of six transistors (the TR82C has seven) These are all Philips/Mullard series germanium PNP types – alloy-diffused in the RF/IF section (AF116N & AF117N) and alloy-junction in the audio stages (AC126 & AC132).

Like most "broadcast-band-only" transistor sets, the 41-47 uses a "cut" tuning gang, with dissimilar aerial and oscillator sections, This removes the need for a padder and allows better aerial-oscillator tracking.

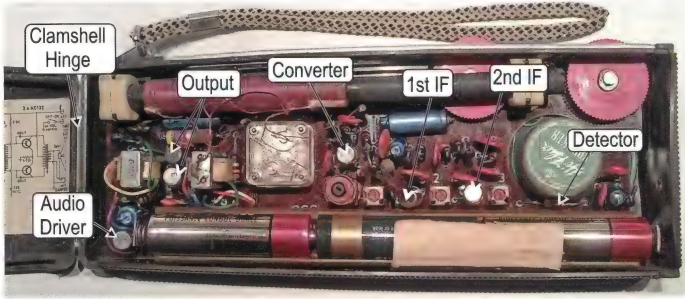
The mixer stage is based on an AF116N and uses collector-emitter feedback, thereby reducing the amount of local oscillator radiation back into the antenna rod. As in the TR82C, this mixer lacks the damping diode included in the original Mullard circuit design to give extended AGC action. Diode D1 (OA91) in the feedback circuit is presumably there to stabilise the oscillator's operation as the receiver is tuned across the broadcast band.

IF stages

The mixer's output feeds the untapped tuned primary of the first IF transformer (IF1). This has a low-impedance untapped secondary to match into the low base impedance of the first IF amplifier stage. The tuning capacitor, by the way, is labelled as "3600" and I suspect that this value (some 20 times higher than normal) is a misprint.

The two following IF transformers (IF2 & IF3) both use tapped, tuned primaries and untapped low-impedance secondaries, with the two AF117N transistors operating as IF amplifier stages. The first stage is biased to operate with a collector current of about 0.5mA. On strong signals, the AGC circuit acts to reduce this bias to reduce the gain.

The second IF operates, as usual, with fixed bias. Note that both stages are biased using a voltage divider and an emitter resistor, to give a predictable operating point and to ensure stability against temperature changes. The emitter resistors are bypassed at the intermediate frequency to prevent degenerative feedback and loss of gain.



This is the view inside the Kriesler 41-47, with the major circuit sections labelled. A large ferrite rod antenna ensures good signal pick-up, while power is supplied by three 1.5V AA cells.

The dial and the thumbwheel-operated tuning and volume controls are all laid out on a panel along one side of the case. This panel also carries a small jack socket for an earphone.

As previously stated, the RF & IF transistors are AF116/117 diffused-junction types. Their feedback capacitance is so low that no neutralisation is needed at 455kHz.

The demodulator is a conventional diode (OA90) at the output of IF3 and the detected audio is fed to the volume control via a 470Ω resistor. In addition, it is filtered using a 4.7kΩ resistor and 6.4μF capacitor to provide the AGC voltage for the first IF stage. The diode's output is positive-going, so it "bucks" the negative bias applied to the first IF base, thereby reducing the transistor's collector current and its gain.

As with all AGC systems, the higher the signal voltage, the greater the gain reduction. The net effect is to keep the audio volume constant so that it is independent of the RF signal strength from different stations.

The audio driver stage (AC126) is biased in much the same way as the IF amplifier stages. However, it uses a much larger emitter bypass capacitor which is effective at audio frequencies.

Output stage

The AC126 drives the primary of a transformer which acts as a phase splitter. Its centre-tapped secondary in turn drives a class-B push-pull output stage based on two AC132 transistors. These then drive the centre-tapped primary winding of the speaker transformer, with the secondary then driving an 8-ohm loudspeaker.

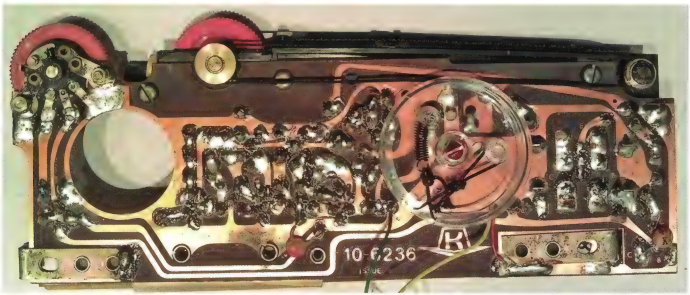
A headphone socket is also wired in parallel with the speaker and automatically switches the speaker out of circuit when a set of headphones is plugged in. Note the 4.7nF capacitors between the collectors and bases of the output transistors. These provide negative feedback at high frequencies, to reduce distortion in the output stage.

A voltage divider consisting of a 3.9kΩ resistor and a 130Ω NTC thermistor normally provides about 160mV of base bias for the output stage. However, as its temperature increases, the thermistor's resistance falls and the bias automatically reduces.

The combined effect of the thermistor and transistor characteristics ensures a fairly constant quiescent collector current in the output stage, regardless of temperature changes. This ensures that the output transistors have enough bias to minimise crossover distortion at all operating temperatures while eliminating the possibility of damage due to thermal runaway.

A small common emitter resistor (4.7Ω) provides some local feedback and helps balance the differing gains in the two output transistors.

In the Bush TR82C, the bias was set via a trimpot to give the lowest possible crossover distortion, a feature that the 41-47 lacks. On the other hand, the TR82C has no form of temperature compensation in its bias network and



This solder-side view of the PCB shows the dial-drive arrangement used in the 41-47. The PCB is easily removed from the case and the set is straightforward to service.

may have been more prone to failure when operated in the extreme temperature conditions often encountered in Australia.

Dead on arrival

When I first acquired my Kriesler 41-47, it was completely dead. One common problem I've found with such sets is corroded/tarnished contacts on headphone jacks and power switches. The 41-47's headphone jack was one such offender but some 800 grade wet-and-dry soon had it clean again. That done, the moving contact in the headphone switch was re-tensioned and the output stage then began working.

This revealed that the volume pot was also noisy but that was easily fixed with a spray of contact cleaner. The set then appeared to be "quiet" – too quiet in fact. Most six (or more) transistor sets have enough gain for mixer noise to be quite obvious at full audio volume but not this one.

Further investigation revealed that the IF stages were badly misaligned. The IF transformers have slotted plastic adjustments and these had obviously been fiddled with by someone who didn't know what they were doing at some stage in the set's past. Careful adjustment with a plastic screwdriver gradually brought the IF stages back to life, the 'noise' increasing as it was brought back into alignment.

Next, I turned my attention to the front-end which was intermittent. The 100Ω resistor between the antenna and the mixer circuit was "touchy" and resoldering it eliminated a dry joint at one end. The tuning was also a bit erratic, due to the tuning-gang shifting about. This was fixed by removing the dial drum and tightening its mounting screws which had become quite loose, after which the front-end alignment was adjusted.

How good is it?

With the radio now operating correctly, I set about checking its performance. This showed that the audio response from the volume control to the speaker terminals is rather ordinary, covering from 210Hz to just 3kHz. The 4.7nF feedback capacitors are among the culprits. They were left in-circuit though, as the three highly selective IF transformers reduce the high-frequency -3dB point to just 1.8kHz.

The audio performance was adequate, with a total harmonic distortion (THD) of around 5.5% at 1kHz for a 10mW output. This THD figure is higher than expected and is partly due to the fact that the output stage bias lacks adjustment. Another common cause is output transistor mismatch although, in this case, the gains of the two AC132s tested within 10% of each other.

At 50mW, the distortion was around 6%, rising to around 7% as the set just begins to clip at 100mW output.

The selectivity is ±23kHz at -60dB or better, which is reasonable. The same goes for the sensitivity, although it's less sensitive than the TR82C which has an extra audio stage. Its best sensitivity figures were obtained at the extremes of the band (ie, 200μV/m at 540kHz and 120μV/m at 1600kHz) but at a relatively poor 15dB S/N ratio.

Again, it's not as good as the Bush TR82C but it is comparable to the 7-transistor Raytheon T-2500.

Unfortunately, the AGC is not particularly good, a 3dB increase in audio output requiring only about an 11dB signal increase (from 1mV to 3.5mV). As a result, it's necessary to ride the volume control when tuning across the band.

The set does, however, withstand RF/IF overload much better than the Bush TR82C. It will accept an RF level of nearly 100mV/m before showing significant distortion due to RF/IF overload.

Summary

While this set is less complicated than the TR82C, it performs quite well for a relatively simple design. It's easily carried in one hand, the tuning and volume controls can be thumb-operated, and the slide-rule dial gives clear and accurate tuning indications.

Basically, it's one of those sets that just begs to be picked up and used. In a word, it's "cool".

Further Reading

If you've not already done so, take a look at Kevin Chant's excellent website at www.kevinchant.com ("Kev's free resource for [mainly] Aussie vintage wireless information, circuits, pictures, parts etc"). There you'll find lots of vintage radio circuits and a great deal of other useful information.

In addition, take a look at Ernst Erb's excellent radio museum site at www.radiomuseum.org SC

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SPORTSYNC AUDIO DELAY	MAY 2011	01105111	$30.00
100W DC-DC CONVERTER	MAY 2011	11105111	$15.00
PHONE LINE POLARITY CHECKER	MAY 2011	12105111	$10.00
20A 12/24V DC MOTOR SPEED CONTROLLER MK2	JUNE 2011	11106111	$20.00
USB STEREO RECORD/PLAYBACK	JUNE 2011	07106111	$20.00
VERSATIMER/SWITCH	JUNE 2011	19106111	$25.00
USB BREAKOUT BOX	JUNE 2011	04106111	$10.00
ULTRA-LD MK3 200W AMP MODULE	JULY 2011	01107111	$25.00
PORTABLE LIGHTNING DETECTOR	JULY 2011	04107111	$20.00
RUDDER INDICATOR FOR POWER BOATS (4 PCBs)	JULY 2011	20107111-4	$80 per set
VOX	JULY 2011	01207111	$20.00
ELECTRONIC STETHOSCOPE	AUG 2011	01108111	$10.00
DIGITAL SPIRIT LEVEL/INCLINOMETER	AUG 2011	04108111	$10.00
ULTRASONIC WATER TANK METER	SEP 2011	04109111	$20.00
ULTRA-LD MK2 AMPLIFIER UPGRADE	SEP 2011	01209111	$5.00
ULTRA-LD MK3 AMPLIFIER POWER SUPPLY	SEP 2011	01109111	$25.00
HIFI STEREO HEADPHONE AMPLIFIER	SEP 2011	01309111	$20.00
GPS FREQUENCY REFERENCE (IMPROVED)	SEP 2011	04103073	$30.00
HEARING LOOP RECEIVER/NECK COUPLER	OCT 2011	01209101	$25.00
DIGITAL LIGHTING CONTROLLER LED SLAVE	OCT 2011	16110111	$30.00
USB MIDIMATE	OCT 2011	23110111	$25.00
QUIZZICAL QUIZ GAME	OCT 2011	08110111	$25.00
ULTRA-LD MK3 PREAMP & REMOTE VOL CONTROL	NOV 2011	01111111	$30.00
ULTRA-LD MK3 INPUT SWITCHING MODULE	NOV 2011	01111112	$20.00
ULTRA-LD MK3 SWITCH MODULE	NOV 2011	01111113	$10.00
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
DIGITAL AUDIO DELAY	DEC 2011	01212111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01212112	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHMODE REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	18104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
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1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
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2.5Ghz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5Ghz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5Ghz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102121	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102130/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DD NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
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(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Head-up display for pre-OBD cars

I read your article on the aftermarket HUDs (SILICON CHIP, September 2013) with interest. Given that GPS versions have what we could term 'drop outs' as well as slow start-up, the OBD version looks superior. Question now is, what if you'd like to fit a wired version to a pre-OBDII vehicle (pre-1996 in most cases)? Could your next project be a converter?

I'm aware that there was less standardisation amongst car manufacturers providing OBDI in their vehicles but there was a loose standard which was common and then manufacturers added their own additional readouts. Plugs also varied and are most often under the bonnet but the wires still came from the ECU units which are usually inside the cabin. For instance, my vehicle is a 1993 BMW 525i with the round 20-pin plug.

I've been able to find software to run on my laptop that reads BMWs and a wide number of other vehicles for fault-finding and they also give a screen dashboard with all the info these HUDs are offering – speed, coolant temperature, fuel consumption etc. I'm lucky enough to have an on-board computer giving me a huge amount of information but it's in the middle of the centre console and worse than looking down to the speedo. So my point is that the wiring is accessible for OBD signals as they come from the ECU.

So what about continuing your article into an adaptor? (S. S., via email).

● That's a big ask, since the essential signals for monitoring in cars without the OBDII socket is not in a standard format, notwithstanding that there is software around to monitor signals in some pre-OBD cars. In any case, even if we were to produce a HUD, it is likely that it would be far more expensive than those presently available from on-line retailers.

Solar Power Is Not The Right Solution

Any chance on articles for the following projects please?

(1) a solar-powered roof exhaust fan (to exhaust hot air from the roof cavity) with a thermostat. The commercial ones in Australia are over $1000 which is way too expensive for a cowl, fan, thermostat and a few cells;

(2) Solar-powered cooling to cool the carport area while I am working; and

(3) Solar power supply for my laptop computer which I have to use in the carport because it overheats in the confines of the house? (J. Q., via email).

● We doubt whether there is much point in producing a solar powered roof exhaust fan since the commercial passive extractor fans are so effective and relatively cheap to install. In Sydney you can have one of these fans installed for $239. Have look at http://www.twista.com.au/

Incidentally, if you think about it, these fans are solar powered.

As for trying to cool an open carport, that would be a huge task for any system, solar-powered or otherwise. Short of planting shrubbery to provide plenty of shade for the carport roof, we cannot suggest any effective approach.

Depending on the power requirements of your laptop computer, a 12V 80W solar panel may do the job. It would need to be shunted by a 4700µF 25V capacitor to reduce its output impedance. Its output will typically be around 17V in full sun; suitable for many laptops.

You would need to carefully check its maximum output voltage under ideal conditions to make sure that it won't go much above the laptop's charge input voltage.

Still, since an 80W panel may cost around $200 or more, a cheaper and more effective approach may be to get a replacement laptop supply which does not overheat. Or simply aim a small fan at it while charging.

Substituting the battery pack in an 18V drill

I have just read your article on "Fire Up Your Cordless Drill" in the October 2013 issue, with interest. I too have a very good old cordless drill but don't wish to spend lots of money on a new battery for it, so I would like to replace it with a Li-Po battery as mentioned.

My question is this: in your article you have used a 22.2V Li-Po battery to replace the original 24V battery. Now my old cordless drill is 18V so is it still OK for me to use a 22.2V Li-Po? Would this higher voltage damage my drill? (K. S., via email).

● In practice, when an 18V Nicad or NiMH battery is fully charged, it is likely to be 24V or more. That answers the question as to whether your drill motor would be damaged by applying 24V to it.

So using a 22.2V Li-Po or Li-Ion battery pack (six cells; 25.2V fully charged) should work well. Five-cell Li-Po packs are also available, with a nominal voltage of around 18.5V and a full-charge voltage of 21V.

Tone control circuits for a future amplifier

Have you come across "sharpened" slope tone control circuits? I read about them in an AES (Audio Engineering Society) paper. I think the compensated 3-pole version would be great for the next SILICON CHIP high-end hifi preamplifier. (O. Z., via email).

● "Variable slope" or "variable turnover" tone controls have been around for a very long time. We think variable slope controls are preferable because they give a much more apparent effect for a given knob rotation.

However, we doubt whether we would ever incorporate tone controls

CLASSiC-D Over-Voltage Protection Should Not Be Changed

I recently finished making a stereo amplifier using two of the SILICON CHIP Classic-D amplifier boards and what a magnificent amplifier that has turned out to be; quiet as a mouse but roars like a lion!

However, my initial efforts were not productive as the mains voltage in my area was consistently too high (too many solar-powered systems in the vicinity, perhaps, including my own!). When I powered up the first board I assembled, the voltage coming out of the power supply was ±62V DC, not ±57V as it was supposed to be. The toroidal transformer was a 40-0-40V type, as recommended in the SILICON CHIP articles, but the mains voltage was 251VAC.

Nothing was coming out of the speaker – that is until I turned the mains switch off! As the DC voltage coming out of the big capacitor bank subsided, the protection relay suddenly switched on and the music flowed for all of about one second. The 60V upper voltage protection limit was kicking in when the amplifier was switched on but dropping below this limit when switched off and eventually (in about 3s) below the lower voltage protection limit of 40V. Clearly, the toroidal transformer was overdoing it.

In fear and trepidation, I unwound the clear plastic insulation from the transformer and proceeded to remove about 10 turns from both secondary windings. This turned out to be quite straightforward and the insulation was easily replaced. The toroid was not as pretty as before but at least the amplifier now worked, and the DC power supply was at a respectable ±55V.

It occurred to me that the existing over-voltage protection could easily have been increased above 60V by using a different resistor but my knowledge of electronic circuits was insufficient. However, the current power supply capacitors have a limit of 63V. Can I increase the over-voltage limit threshold? (R. R., Canberra, ACT).

● We do not recommend increasing the over-voltage protection limit. Your solution to remove turns from the secondary is a wise idea, to reduce the supply voltage to the amplifier when the mains peak voltage is consistently high.

The peak of the mains waveform is the determining factor of the rectified and filtered supply. Mains waveforms that are "flat-topped" will provide a lower rectified and filtered transformer supply voltage for a given measured RMS mains voltage compared to a mains supply that has a normal sinewave shape.

Many, if not most, supply areas exhibit a flat-topped mains waveform and so the 40-0-40V transformer should be suitable for those regions. For the higher peak voltage regions, your suggestion to remove turns from the transformer secondary to reduce the overall DC supply to ±57V is the best approach.

in a hifi preamp as we don't think they're really necessary.

Wrong inductor in frequency counter

I built the 2.5GHz 12-Digit Frequency Counter (December 2012-January 2013) using PCBs and parts from the SILICON CHIP shop. It seems I have been supplied with an ADCH-80 inductor instead of ADCH-80A as specified in the parts list. This has a different pin configuration; the coil is connected to the middle two pins on each side rather than pins in opposite corners. Otherwise it seems to be identical.

Can I use the ADCH-80 in place of the ADCH-80A by bridging pins 2 & 3 and 5 & 6 to connect the coil to the appropriate pads on the PCB? I assume this will increase the parasitic capacitance (ie, unwanted capacitance in parallel with the coil). Will that negatively affect performance?

Just what is the role of inductor RFC3 anyway and why did you use a hard-to-get part like this rather than a standard surface-mount "chip" inductor? (G.L., Hobart, Tas).

● Our apologies for supplying you with the wrong part but we think it should work fine if you solder it across the pins as you suggest. The ADCH-80 and ADCH-80A both specify parasitic capacitance as being about 0.1pF (in fact their specifications are identical except for the pin connections). Our calculations show that this capacitance will reduce the gain of the amplifier (IC1) by approximately 0.06dB at 2.5GHz compared to a theoretical ideal inductor that had no capacitance.

You are right that bridging the pins will probably increase this capacitance slightly as it means that the two pads under the coil are effectively larger. Having said that, the connected pads of the ADCH-80 are significantly closer together than those of the ADCH-80A and yet the specified capacitance is the same so this must not be very strong effect. Let's say doing this increases the capacitance by about 30%, to 0.13pF.

Re-running those calculations, the reduced load impedance at 2.5GHz only reduces the gain by a further 0.04dB, to 0.1dB. This is quite insignificant and so unlikely to impact the performance to any noticeable extent. Even if the capacitance is doubled, to 0.2pF, that only reduces the gain over the typical case by less than 0.2dB.

Inductor RFC3 forms part of the load and power supply for microwave amplifier IC1. The ERA-2SM+ data sheet says that using a radio-frequency choke here is optional, ie, you could short RFC3 out and the circuit should still work. But including RFC3 has a number of important benefits, the most important of which is significantly better gain in the amplifier stage.

This is because with RFC3 in circuit, IC1 drives a higher load impedance, ie, its output is more lightly loaded. Its output load impedance is the impedance of what it is driving (in this case, pin 1 of IC2) in parallel with the impedance of the network at its output that gives it a DC supply current – in this case, RFC3 in series with the 47Ω resistor.

With just a resistor, this impedance is fixed and typically the load impedance is too. But the impedance of an inductor rises with frequency, so RFC3 has a low impedance at DC in order to supply IC1 with its operating current but a high impedance at RF to ensure that it doesn't load down IC1's output transistor. RFC3 also provides high frequency isolation between IC1's output

Power Factor Is Ignored In Electricity Bills

What are the implications of a poor power factor in a switchmode power supply?

I have a 12V 5A power adapter (from eBay) powering an ultra-low-power PC. I thought my Watts Clever power meter must have been wrong when it said the computer was only using 20W at idle. So I bought a CCI Power-Mate Lite. To my surprise it said the computer was only using 15W. But it said that with a power factor of 0.5, it was using 30VA.

So am I being billed by my electricity company for .015 kWh/hour, or .030 kWh/hour? And would that power adapter be at the maximum power it could deliver if the load on it was quadrupled, or only doubled? I can see that when the PC goes to sleep and is only drawing a couple of watts, the power factor gets even worse. Does it get better as the load approaches the switchmode power supply's maximum load?

I understand it's a moot point with a power adapter and PC that small. But I'm powering bigger things with switchmode power supplies, as we all are, and the same principles would apply, just with bigger numbers. (G. D., Burton, SA).

- The first point is that your power company charges you for watt-hours used and ignores power factor. In other words, you are not charged for VA. So the rest of this answer is of academic interest only.

It's unlikely that the supply you bought has active power factor correction (PFC) so the power factor will be poor when only a small proportion of its rating is being used. As a corollary of that, its power factor will be best at full load but it will still be lousy when compared to the unity power factor of a resistive load.

Switchmode supplies with active PFC are much better and may have a power factor approaching unity across a wide range of loads, although it still usually drops somewhat for light loads. This type of supply tends to cost more but most modern PC supplies have active PFC. By contrast, generally low-power switchmode power supplies directly rectify and filter the mains voltage using a diode bridge and filter capacitor. The capacitor is effectively charged to the peak of the waveform and charge currents are quite high and only occur around the waveform crests. The current remains essentially in-phase with the voltage.

The power factor value provided for this type of current and voltage waveform is the apparent power factor. That is the ratio of real power to the RMS voltage times the RMS current.

For this type of supply, the only way to accurately measure the real power is to calculate the sum of the instantaneous voltage multiplied by current over each cycle of the waveform. Apart from measuring the instantaneous voltage and current, an accurate watt meter would need to have the ability to accurately read the high crest factor (ratio of the peak current to the average current) of the supply. The Energy Meter published in the July and August 2004 issues of SILICON CHIP accurately measures high crest factor waveforms.

and the 5V supply rail, reducing the chance of feedback through the power supply or noise coupling.

As for why the ADCH-80A in particular was used, it can operate at much higher frequencies than typical inductors. Its insertion loss at 10GHz is a staggeringly low 0.42dB while a standard ferrite or powdered-iron core inductor will rapidly become lossy above 1MHz, primarily due to core losses but also excess parasitic capacitance. Given that the ADCH-80A is such a good performer and we're already specifying a part from Mini-Circuits (the ERA-2SM+ amplifier IC), it isn't much of a stretch to use it in this role.

Making a vacuum pump

Neno Stojadinovic wrote an article in March 2011 on converting a refrigerator sealed unit to a vacuum pump. He indicates that the oil should be changed but does not say why. Is this really necessary please? (G C., via email).

- You need to change the oil because the original refrigeration oil will froth violently under vacuum and then it will spray out of the exhaust hose.

It also follows that a good vacuum depends on good oil. The best vacuum will be obtained with brand new oil

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

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and increasing levels of contaminants will progressively reduce the ultimate vacuum that the pump can achieve.

Preamp for a ceramic phono cartridge

I have a large collection of 33 and 78 RPM discs which I want to dub to compact disc. To do this, I propose to use my old BSR record changer which has a turn-over ceramic cartridge. However, it gives virtually no bass when I feed its signals into the line inputs on my amplifier and it overloads the magnetic cartridge inputs as well, so there is no way I can match it to my amplifier.

I thought about using your universal preamplifier (SILICON CHIP, April 1994) but it does not appear to cater for ceramic cartridges. Is this possible? (J. P., via email).

● We have not published a preamplifier project to suit a ceramic cartridge, partly because there has been so little demand, although having said that, musicians also have a need for this type of preamplifier if they are using a violin with a ceramic pickup.

However, we did publish two simple preamplifier circuits in the Circuit Notebook pages of the June 2002 issue which should suit and either of these would be easy to build on a piece of Veroboard. The first was based on a TL071 FET-input op amp while the second was based on a BC549C high-gain low-noise NPN transistor. The circuits were mono only, so if you wanted a stereo version you would use a TL072 dual op amp or two BC549Cs; one for each channel.

Planet Jupiter Receiver Overloaded By Transmissions From Earth

I constructed a kit for your Planet Jupiter Receiver from the August 2008 issue. I live in Bundaberg, in Queensland and it receives a strong signal from Radio Australia originating from Melbourne. I can't get rid of it!

I am confident the coils are wound correctly. Tuning the trimmers (6-30pF) doesn't make much difference and VC3 certainly makes no difference at all. The receiver is well earthed and all voltages check out. Any ideas? (R. R., via email).

● It does seem that you are particularly unlucky in getting such a strong interfering signal from a Radio Australia signal originating in Melbourne (and presumably being beamed in your direction).

Unfortunately the Planet Jupiter Receiver doesn't have particularly good selectivity, so there's not a great deal you can do to fix things in the receiver itself. However here are a few suggestions: (1) make sure that your antenna is 'side on' to the South, so it will have less sensitivity in the direction of Melbourne; (2) try making up a small 'tuned trap' which can be connected between the antenna and the Planet Jupiter Receiver's antenna input, to specifically reject the Radio Australia signals– see www.mydarc.de/dk7zb/Trap/trap.htm

If you make the trap with a fairly high Q and couple into it and out of it quite loosely, this may do the trick.

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Shorted Amplifier Outputs Can Cause Damage

I made an Ultra-LD Mk.2 power amplifier a few years ago. It worked well until by accident I shorted out one side. It blew the fuses and all output transistors proved to be faulty. I checked all the other transistors with the output transistors removed and they were OK.

Having fitted new output transistors, with safety resistors in place of fuses, it drew too much current from the supply. I compared the circuit voltages to those shown in the circuit and they were very close; the output transistor isolation from the heatsink also tested OK. There was a blob of solder across the diode in one of the output transistors which I did not notice but it's gone now.

The voltage across the diode string is now 1.8V. Any idea what could still be wrong? (J. V., via email).

● The damage could be more widespread than just the output transistors (Q12-Q15). Check the 100Ω base resistors for transistors Q10 and Q11. Also, Q10 and Q11 may need replacing.

Check that diodes DQ12-DQ15 have voltage across them. The 1.8V total for the diode string seems low but that could just mean that the diode current needs to be increased by changing Q7's 68Ω emitter resistor (see page 71 of the September 2008 issue).

Both circuits have a very high input impedance, necessary in order to provide good bass response from ceramic cartridge which can be regarded as a voltage source in series with a capacitance of around 500pF or thereabouts.

Fuel economy indicator wanted

I want to fit a permanent injector pulse width indicator to my vehicle, a 2006 Mitsubishi Pajero 3.8-litre petrol V6. This is intended as a fuel economy indicator, especially for caravan towing.

I am convinced such a unit would have wide appeal if promoted to the caravanning fraternity, should you produce one. (E. J., via email).

● The best way to get an indication of fuel economy in a modern car is to fit an OBD HUD. This topic was covered in detail in the article on HUDs (head-up displays) in the September 2013 issue.

We actually described a fuel injector readout back in August 1995 and it was a Jaycar kit but it has long since been discontinued. We could revive it but any new circuit would have to include a clear indication of fuel injector cut-off. This happens in most modern cars with no throttle input (ie, foot off the pedal) and above a threshold speed but may be disabled if the engine is cold.

The recent GPS Car Computer project (Silicon Chip, January & February 2010) was able to provide an indication of fuel economy, based on the injector duty cycle. However note that its display is relative (a bargraph) rather than an absolute read-out in l/100km. A kit is available from Altronics, Cat K1133.

SLA batteries have limited shelf life

I built the Emergency 12V Lighting Controller (Silicon Chip, January 2008) and it worked great for three years, just as you described. Well, we just had a blackout and I noticed that my emergency lights were not on. I was thinking that they had run the battery down so it has switched off to save damage to the battery.

However, after investigating and re-testing and checking all components, just as I did when I first built the unit, I noticed that the lights go off by themselves after about 45 seconds, so it could have been like this since I first built it. The battery was changed but the good new battery is doing the same thing.

Have there been any other builders that have mentioned this problem? Can the switching off be adjusted by changing the values of components? I have measured all components to see if there was a faulty one but all are OK; the zener diode is the right one and the Mosfet is OK.

It's very strange that it's doing this. The lights work when I connect them directly to the battery and stay on until I disconnect them. (R. S., via email).

● We are not sure from your description just what is going on. It sounds as though you need to do a few voltage checks, preferably when running the circuit from an adjustable DC supply rather than the 12V SLA battery.

The first point to check is that the circuit works OK when the 'battery' voltage is more than 11.6V. To set this up, you need a good SLA battery (ie, one charged up to 12V or more) or an adjustable DC supply delivering 12V or a little more and you also need the charger connected, as per normal.

Now kill the power to the charger, to simulate a blackout, and the lights should come on and stay on. If you have an adjustable power supply connected instead of the SLA battery, reduce its output voltage to below 11.6V. The lights should go out. If so, the circuit is working as it should (the circuit is quite simple and has proved to be quite reliable as we have not had any complaints about it).

On the other hand, if the circuit works OK under this test but misbehaved with your battery (both old and new), then the batteries are suspect. If they are not used and kept on float charge (as this circuit does), they do deteriorate to the point where they may apparently measure OK but 'die' as soon as you connect a significant load.

The same comment applies to any SLA battery that you may have purchased new. If it has been sitting on the shelf for many months, it may not be able to deliver its rated current for more than a short period of time.

Electronic mobility reminder needed

I have an idea for a future project. The medical profession are increasingly worried about the amount of time modern workers spend sitting, usually in front of a PC. As someone who has taken this message to heart, I have come across a major problem that may yield to a technical solution, namely, I forget to stand up every hour or so.

It is so easy to become engrossed in an interesting activity or find yourself enslaved to a deadline, that remembering to stand up and move around regularly is harder than one might imagine. Under such distractions it's even hard to remember to set an alarm, so an automated system is required to gently remind the sitter to rise

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and move about at intervals.

I feel a device that attaches to the chair is required. Functionally, it may perform something like:
(1) emits a gentle beep when someone sits down to alert them that the system is active and remind them that prolonged sitting is dangerous;
(2) the device integrates the total sitting time and standing time so that a maximum value of sitting time per hour is allowed (this varies, depending on which medical researcher's view you subscribe to);
(3) As the limit time approaches, the device emits a series of increasingly urgent beeps. If you only stand for half

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the recommended period, then the threshold will be reached again in half the time. If you stand up frequently for short periods (which is medically better), then you may never trigger the alarm;

(4) If you really must stay seated, then a button allows you to reset the alarm, but only for a 'snooze' period. Given how much chairs move around, the device should be battery-powered. But considering the measured time intervals are so long, there is no reason for the device to be in 'detecting bum' mode continuously. A low battery alarm should be included.

The implementation is of course, up to the designers but a few ideas suggest themselves. The majority of chairs have non-metallic seats, so a proximity detector placed under the seat should easily detect a person sitting on it. A capacitively-coupled source and detector might do the job. Some form of learning or initial calibration might be necessary to take into account different chair materials. I know of no such commercial device, so can SILICON CHIP come up with a first of kind? (M. H., via email).

● We have been aware for years about the health dangers of sitting for long periods without moving around. It does not just apply to people in front of a PC though.

It's possible to set up a regular reminder on your computer using free software but we don't think that a timer, simple or complex, would be the answer. You simply have to change your mindset, to move around as much as possible, to avoid seizing up!

Anyway, we have published your suggestion, in order to gauge reader reaction. SC

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